Vol. XLIX

TABLE OF CONTENTS.

No. 7

(28 pages; no inset.)

Page

ENGINEERING NEWS OF THE WEEK 137

LEADING ARTICLES:

The Central Railway of Nicaragua (illustrated) ..... Emil Mueller, C. E. 138
Methods of Choosing City Engineers 138
The Briquetting of Flue-Dust, Fine Ore and Fuel (illustrated) 140
The Inauguration of President Alexander C. Humphreys at Stevens Institute (With Portrait) 146
The Relations Between Engineers and Contractors ..... A. C. E. 146
The New York Rapid Transit Railway, XVI., Contract Section XI. (illustrated 147
How to Pan Gold from Gravel 149
Notes from the Engineering Schools 153
A Sanitary Survey of Mill Creek Valley, at and Near Cincinnati, Ohio 154
A New Type of Steam Roller (illustrated) 154
The New Ore-Dressing Laboratory at Columbia University, New York City 155
Computing the Strength of Concrete-Steel Beams ..... Edwin Thacher, M. Am. Soc. C. E. 156
A Graphical Method for the Calibration of Irregular Vessels (illustrated) ..... Arnold Emch. 158
Current Meter Ratings and Observations by the U. S. Irrigation Investigations Department (illustrated) 158
John Benjamin Henck (With Portrait) ..... Geo. F. Swain, M. Am. Soc. C. E. 160
Wood Pavement on the Driveway of the Brown & Sharpe Manufacturing Co. (illustrated). 160
Plant and Methods Employed in Excavating Ambrose Channel, New York Harbor 161
Progress of the Topographic Mapping of the U. S. Geological Survey (illustrated) 162
A Concrete-Steel Culvert for Stream Diversion at Kalamazoo, Mich. (illustrated) ..... Geo. S. Pierson, M. Am. Soc. C. E. 163

EDITORIAL COMMENT.—An Obstacle in the Way of Municipal Ownership of Gas Works—A School of Gas Engineering Needed—The Relations Between Engineers and Contractors—Limitations to "Home Rule" in Municipal Government—The Coroner's Investigation of the Westfield Collision 150

EDITORIAL.—The Prolixity of Some U. S. Geological Survey Monographs 151

LETTERS TO THE EDITOR.—Some Suggestions on Concrete-Steel Construction: W. W. Christie—Another Method of Finding a Tangent to Two Circles (illustrated): Henry A. Wolcott—Uniform Tests of Cement; Correction: Richard L. Humphrey—Instance of Rapid Wear of a Wire Elevator Rope Subjected to Reversed Stresses (illustrated): G. M. Campbell—Some Possible Substitutes for the Metric System as a World System of Weights and Measures: C. R. Coutlee—Another Reply to Mr. Porter's Letter Against the Metric System: A. T. Hubbard 151, 153

THE METRIC BILL BEFORE CONGRESS has been withdrawn. The reason for its withdrawal is claimed not to be a lack of votes necessary to its passage, but a desire to win over its strongest opponents before its passage later. The bill is to be reintroduced early in the Fifty-eighth Congress, when the Senate Committee will give it a hearing. The bill provides for making the metric system "the legal standard" of weights and measures in the United States.

A BILL TO AMEND THE U. S. MINERAL LAWS is to be introduced in the House of Representatives by Mr. W. H. Douglas, of New York. The bill provides for square claims, 660 ft. on a side, containing 10 acres. It provides for the gradual abolition of the so-called "extra lateral rights," and the repeal of the "apex clause," which have been the cause of innumerable law suits.

STATE REGULATION OF ELECTRIC RAILWAYS is discussed as follows in the annual report of Mr. F. G. Ewald, Consulting Engineer to the Illinois Railroad and Warehouse Commission:

Referring to the comparative tables in the report concerning surface and elevated electric railways, there appears an increase of 165.71 miles of line over that reported for the previous year, as a result of annual reports from some of the companies who have reported to this Commission for the first time. Nearly all of the 15 electric lines which have reported are incorporated under the general railway laws of the state, and the total mileage of these lines amounts to 211.40 miles of first main track, or a total of 352.35 miles of tracks of all kind. As a matter of fact, this mileage represents only a small portion of the mileage of such lines, and the recommendations previously made that the owners and operators of electric interurban lines be amenable to the jurisdiction of the Railroad and Warehouse Commission to the same extent as steam railway companies (whether incorporated under the general railroad laws or any other legislative act) are again urged. For the lack of any direct information it is impossible to say authoritatively what the total mileage is, and the capitalization which such lines represent, as in existence at the present time.

From a statistical point of view, if for no other reason, the owners and operators of urban lines should also be under the jurisdiction of the Commission to a limited extent, thus making it possible to secure in the form of annual reports, information concerning mileage, capitalization, earnings, expenses, etc. As matters stand at the present time, there is no public office in this state where access may be had to the records of all classes of railways, and where one may secure statistical information concerning all electric urban and interurban lines, and it would therefore not only seem feasible, but desirable, that some legislation be enacted concerning the status of all electric lines in relation to the Railroad and Warehouse Commission.

AN APPROPRIATION OF $14,033,851 FOR DOCK construction is asked by Mr. MacDougall Hawkes, Commissioner of Docks of New York city. The bulk of this sum is to be expended in the Chelsea improvement, which calls for the construction of a new system of large docks and piers between Gansevoort Market and 23d St., on the North River.

THE EXPLOSION OF FOUR BOXES of dynamite detonators, on Feb. 5, at the Bridesburg freight yards of the Pennsylvania R. R., blew a man and two horses to fragments. Houses nearby were partly wrecked and a score of occupants injured. The workshop of the Frankford Arsenal, which had just been rebuilt after the explosion of a few weeks ago, was again wrecked. A man and a 12-year-old girl are perhaps mortally injured. The explosion is said to have been caused by the jolting of the wagon carrying the detonators as it struck a curb.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between two freight trains on the Chicago, Rock Island & Pacific Ry., near Tecolote, N. M., on Feb. 5. No details of the accident are at hand, except that the collision took place on a heavy grade. Five persons were killed in the wreck.

GREAT LOSS OF LIFE is reported from the Society Island group, in the South Pacific Ocean. On Jan. 13, 1903, a great tidal wave swept over the islands, the larger part of which is very low. This wave was accompanied by a great storm, which lasted for a number of days. It is estimated that over 1,000 persons were killed; the survivors are left entirely destitute.

ANCHOR ICE INTERRUPTED THE ELECTRICITY supply of Appleton, Wis., on Jan. 30. The turbines driving the generators were clogged and for about three hours the city was dark. The reserve steam engine was started by that time and supplied the lighting service.

A NEW DISCOVERY IN WIRELESS TELEGRAPHY has been announced by Prof. Ferdinand Braun, of Strasburg University, before the Strasburg Scientific Society. Prof. Braun claims to be able to generate electric waves which he can project through space "exclusively to any desired point of the compass," as the daily papers have it; but reading between the lines it appears more probable that he only claims a more perfect tuning of the transmitting and receiving instruments than is obtained in other systems of wireless telegraphy.

A SELECTIVE METHOD OF WIRELESS TELEGraphy has been invented by a Norwegian professor, Mr. Anders Bull. In a recent number of the "Electrician," of London, he describes the method and reports the results of some laboratory tests of the apparatus. The system is mechanical in nature, and depends upon converting the dot of the Morse alphabet (the dash is taken as a double dot) into a series of impulses which are sent out as "wireless" wave impulses. The arrangement of this series of impulses constitutes the characteristic of the station; that is, the relative intervals between the various impulses in a single "dot" series have definite values different for each pair of stations, or rather for each line of communication. At the receiving end these impulses are all separately received by the air-wire coherer, and relay circuit, but from this circuit an apparatus called a "collector" receives and records the impulses only if they form series corresponding in arrangement to the station characteristic. This is done by a rotating disc carrying many auxiliary projecting steel springs arranged on the circumference of a circle. At each impulse received in the relay circuit one of these springs is attracted radially inward into a circular guide channel; if the series of impulses is properly arranged springs will be thus attracted at such intervals around the circle that they simultaneously close a set of contacts, connected in series, through which the final recording circuit is closed momentarily so as to record a dot. If individual springs are attracted in an order slightly different from the arrangement of the contacts, they will fail to close these contacts simultaneously and the recording circuit does not register. The sending instrument, called "disperser," is similar to the "collector." One dot can be transmitted with each revolution of the disc. It is possible by employing comparatively short series of impulses, say 3 to 6 impulses in the series, to send idle impulses between successive series, so that an "untuned" receiver will register only a continuous succession of dots. Thus an absolute secrecy of transmission can be had, its security lying in the number of permutations possible in the series. It is thought that in practical working difficulty will be had in rotating the discs at different stations synchronously. Mr. Bull reports that in his experiments with the apparatus he was able to send as high as 50 letters per minute.

GERMAN ELECTRICITY WORKS in 1902 numbered 870, with a maximum capacity (dynamos plus storage batteries) of 438,772 KW. The average capacity per plant was therefore 504 KW. It is noted that over half, 472 plants, had a capacity of less than 100 KW., 69 exceeded 1,000 KW., and 13 of these exceeded 5,000 KW. Steam engines were the exclusive source of power in 509 works. The entire connections to the works aggregated 425,300 KW., of which one-half consisted of incandescent lamps and about one-third of motors.

A TRUNK SEWER for the Lower Passaic Valley, with an outlet into New York Bay, "within the limits of the State of New Jersey," and with sewage treatment works "when necessary," is authorized by Assembly Bill No. 57, introduced in the New Jersey legislature on Jan. 26 by Mr. R. M. Boyd, Jr., of Montclair. The bill applies to the Passaic Valley sewerage district, created about a year ago, and continues in office the district commissioners appointed under that bill. An expenditure of not over $9,000,000 is authorized by the bill, and the commissioners are given sole jurisdiction over the pollution of the Passaic River and its tributaries, with the right of application to the chancery court for injunctions to enforce its ruling or orders in matters of pollution. The bill is in accord with the report of the district commissioners, briefly outlined in our issue of Jan. 29. Mr. Julius A. Lebkuecker is Chairman and Mr. John S. Gibson is Clerk of the Passaic Valley District Sewerage Commission. Mr. Rudolph Hering, M. Am. Soc. C. E., of Hering & Fuller, New York City, conducted the engineering investigations made for the commission last year. The chief opposition to the bill comes from Paterson, which has fought all propositions for a trunk sewer from the start, and which is urging that the State ought to contribute largely towards whatever expenditure is made to abate the pollution of the Passaic River. The bill recognizes the possibility of State aid by providing for the expenditure of any moneys separately appropriated by the legislature to aid in the work.

THE ORE PRODUCTION OF ROSSLAND, B. C., for the last year was 1,000,000 tons, valued at $20,000,000.

ALASKA GOLD GRAVELS on Seventy-Mile River are reported by William Fitzhugh, a mining expert for a London company, to average $2 per cu. yd. with $500,000,000 in sight that can be recovered at a cost of 20 cts. per cu. yd. by hydraulic mining. Mr. Fitzhugh predicts an Alaska gold output exceeding that of the Rand after 1905.

AN ANTHRACITE COAL VEIN, 4 ft. thick, is reported as having been discovered on Bear Creek, Madison county, Montana.

THE COPPER BESSEMERIZING PATENT, granted to Pierre Manhes in 1892, was declared invalid, on Jan. 31, by Judge Knowles in the United States Court at Helena, Mont. An action for damages had been brought against the Boston & Montana Mining Co. for alleged infringement. The court held that there was no invention in merely applying the Bessemer steel process to copper. The effect of this decision is far reaching, for the Manhes process is widely used.

A SYSTEMATIC STUDY OF UNDERGROUND WATERS is to be undertaken by the U. S. Geological Survey, or perhaps it might be more correct to say that the studies previously made are to be continued on a more extensive and systematic plan. The work will be carried on by a new division, the hydrological, and will be in charge of two geologists—Mr. N. H. Darton for the Eastern section, including the Mississippi River and the Gulf states, and Mr. M. L. Fuller for the Western section. Records of wells of all kinds will be secured and filed, together with all possible information bearing upon the sources and yields of underground water. Following the study of the geological aspects of the subject in the West it is proposed to sink test wells in that section.

THE CENTRAL RAILWAY OF NICARAGUA.

By Emil Mueller, C. E.*

The Central Division of the railway system of Nicaragua was practically completed in November, 1902; and with this section Nicaragua now has a continuous railway line from Corinto, on the Pacific, to Granada, on Lake Nicaragua, with a branch to Diriamba, in the coffee region. The

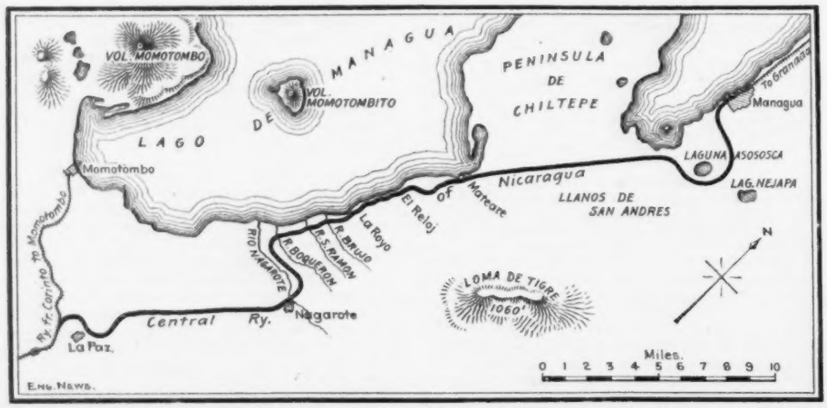


FIG. 1. MAP OF THE CENTRAL DIVISION OF THE GOVERNMENT RAILWAYS OF NICARAGUA; SHOWING THE CONNECTION BETWEEN THE PREVIOUSLY CONSTRUCTED CORINTO-MOMOTOMBO AND MANAGUA-GRANADA RAILWAYS.

Julius Wiest, M. Am. Soc. C. E., Chief Engineer and Contractor; Emil Mueller, Assistant Chief Engineer.

total system in operation is 160 miles long; and the elimination of the expensive steamer transfer across Lake Managua will enable the Government to make a considerable reduction in freight and passenger rates between the lake and the Pacific.

The accompanying map shows the location of this new division, connecting the previously built railways from Corinto to Momotombo, and Managua to Granada. Leaving the Eastern Division at Managua the line runs south and ascends the south side of the old crater-lake of Asososca, four miles from the starting point. The line winds along the edge of the crater, generally in deep cuts, and at an elevation of about 350 ft. above the water surface of the lake.

The crater of Asososca is about half a mile in diameter, and is filled with absolutely pure water which sooner or later will be used for the water supply of Managua. The elevation of this crater-lake is 154 ft. above sea-level, or about 17 ft. above Lake Managua. Leaving this crater, the line strikes the shore of Lake Managua at Mateare, and skirts the lake for some distance. Nagarote, 27 miles from Managua, is the more important of the villages on the new route; and after leaving this place the line passes partly through good timber land and partly through swamps. At La Paz the road connects with the old line to Corinto.

The climate in this section is hot, owing to the slight elevation above the sea; and though subject to malaria at the end of the rainy season, the country cannot be considered unhealthy. The average annual rainfall varies from 40 to 60 ins. Good water can be obtained almost anywhere at a depth of 20 to 50 ft. below the ground level; and several small rivers flow into the lake between Nagarote and La Royo. Agriculture and cattle-raising form the chief occupation of the natives.

President Zelaya, on Nov. 1, 1900, signed a contract with Mr. Julius Wiest, M. Am. Soc. C. E., of Managua, for the construction of this Central Division. The contract price was fixed per English mile in Nicaragua currency, and the government obligated itself to furnish the ties, rails, spikes, switches, etc. During construction, Mr. Wiest acted as Chief Engineer, with the writer in immediate charge of construction; Messrs. Adolfo Cardenas and William Neuhaus were the assistants of the latter. The grading was in charge of Dr. Bruno Mierisch, and Mr. Wm. Simpson was superintendent of track-laying. Two years were allowed for the completion of the work; and for the first time in the history of government contract work in Nicaragua the railway was finished within the stipulated time.

*Managua, Nicaragua.

The material handled was of volcanic origin, consisting of pumice, ashes and sand, with considerable clay towards La Paz. The cuts are 15 ft. wide at the base, with the usual slopes; the embankments are 12 ft. wide on top. Some of the cuts are 60 to 80 ft. deep on the center line; and some of the embankments are 50 ft. high. All the streams are bridged with 38-ft. plate girders resting upon substantial masonry abutments. There are four bridges of this type, the highest being 30 ft. above the river bed; there are in addition four smaller girder bridges ranging from 10 to 20-ft. span. In other depressions 12 to 24-in. sewer pipe are used for passing water through the fills; and in a few cases regular masonry culverts were built, or 3 × 5-ft. tunnels were driven through the rock on the side of the fill. All of this work was performed by native labor on the individual contract system, and with the assistance of three miles of Decauville portable railway. The elevations and distances on the Central Division are:

Cities.	Distance.	Elev. above sea level.
Managua	0.0 miles.	154 ft.
Mateare	15.32 "	187 "
Nagarote	26.89 "	260 "
La Paz	36.23 "	225 "
Junction	37.71 "	271 "

METHODS OF CHOOSING CITY ENGINEERS.

In our issues of July 24, Aug. 7 and Oct. 23, 1902, there appeared, successively, an editorial note, a letter from Mr. Emmett Steece, Assoc. M. Am. Soc. C. E., City Engineer of Burlington, Ia., and a letter from "G. M. B.," of Salt Lake City, on the relative merits of selecting city engineers by popular vote, by mayoral appointment, or by vote of the city council. First of all, we questioned the advisability of a provision of a proposed new charter for Atlanta, Ga., under which the city engineer was to be elected by popular vote. Mr. Steece favored popular elections, as leaving the engineer freer from political entanglements and personal obligations than he is when selected by either the mayor or the council. Finally, "G. M. B." seemed to be against direct election by the people, urging that a nominating convention well enough informed to choose the right man for city engineer can be depended upon to nominate mayor and council of proper number to make a good choice, and a mayor's chances of knowing the qualifications of engineers are superior to those of conventions at large.

FIG. 2. THE VOLCANOES OF MOMOTOMBO AND MOMOTOMBITO, LOOKING ACROSS LAKE MANAGUA.

An extensive addition to the discussion of this interesting subject has been made by Prof. A. Marston, of the Civil Engineering Department of the Iowa State College, Ames, Ia., and Mr. G. W. Miller. These gentlemen recently secured both opinions and facts from the city engineers of 25 American cities, distributed over the country, and presented the results of their inquiry, with comments thereon, to the annual meeting of the Iowa Engineering Society, held at Ames, Ia., on Jan. 21-3, 1903. Presenting practice first and the opinions of the several correspondents afterwards, the authors give a table, reprinted herewith, showing the manner of selecting both city engineers and their assistants in the 25 cities heard from. The table also gives the tenure of office of the city engineer in each of the cities. The most common practice, it will be seen, is appointment by the mayor (9) or commissioner of public works (4), as against election by the people (8). Selection by the city council and by civil service procedure have but two cases each.

The letters from the several city engineers give a variety of arguments in favor of one or the other of the two principal methods of selection, either election or appointment. These may be abstracted as follows:

Emmet Steece, Burlington, Ia.—Mr. Steece gives some of the same general arguments in favor of popular elections as were advanced by him in our issue of Aug. 7, 1902, but he also suggests appointment for a ten-year term, after examination, moral character and technical education each to have weight. By technical education he does not mean that the applicant must have a diploma.

E. W. Case, Colorado Springs, Colo.—Thinks "the people as a whole are better able to select engineers than a board, clique, or any other set of men, few in numbers," whose actions are largely governed by motives of self-protection.

G. L. Campen, Lincoln, Neb.—Considers the engineer elected by popular vote under obligations to no one. That practice in Lincoln has resulted in the office being a non-political one.

J. M. Lewis, Sioux City, Ia.—Favors popular elections, although stating that the office there is a political one. Thinks the incumbent may nevertheless keep free from the "baneful influence of party politics" if he is a man of "ability, integrity and tact."

S. L. Etnyre, Council Bluffs, Ia.—The office should be kept free from politics, but he does not see how this can be done.

C. P. Chase, Clinton, Ia.—Experience here shows that popular election "from a merit standpoint is a failure," since any one who hus-

tles can be nominated and a nomination by the winning party means election. In the past ten years there have been five inexperienced engineers as candidates in Clinton, two of whom were elected. Favors civil service selection, with none but State licensed engineers eligible to office.

W. J. Hardee, New Orleans, La.—Until two years ago the office of city engineer here was filled by appointment. The appointee and his work so vitally affected the success of the administration that, save for several exceptions years ago, only fit men were chosen.

B. T. Fendall, Baltimore, Md.—Appointment, as practiced here, "works well, provided the mayor and city council do their duty." All depends on the character of the appointing officials.

J. A. Omberg, Memphis, Tenn.—Unaware of any way "by which merit alone can place a man in this position," which is filled by the mayor.

Chas. J. Poetsch, Milwaukee, Wis.—The civil service plan, which was established in 1896, and governs employees only, has "given general satisfaction."

Andrew Rosewater, Omaha, Neb.—Thinks the best results would be secured if the appointment of the city engineer was made in the middle of the mayor's term, "to enable the mayor and council to familiarize themselves with the competency of the incumbent, and to remove the engineer from the immediate effect of campaign promises." Employees "should be retained on civil service rules."

L. W. Rundlett, St. Paul, Minn.—Has always favored civil service rules, "except, perhaps, heads of departments."

G. W. Sublette, Minneapolis, Minn.—Favors popular election.

C. M. Morse, Buffalo, N. Y.—Appointment by commissioner of public works, appears to be satisfactory, and selection of employees by means of civil service commissioners is good "so long as we are able to have proper men in office."

Julian Griggs, Columbus, O.—Believes employees in the department of civil engineering should be selected under the civil service plan, and that neither the chief or assistant engineers should of necessity be residents of the city.

R. W. Waddell, Kansas City, Mo.—Appointment by the board of public works seems to work well, but civil service methods are the only known way of keeping appointments out of politics.

Jas. C. Travilla (Office Superintendent), St. Louis, Mo.—If the city engineer refrains from affiliating with any political organization and attends strictly to his duties, politics, in time, will not enter into the appointment.

C. E. Grunsky, San Francisco, Cal.—The civil service plan for employees has proved satisfactory.

John Ericson, Chicago.—No opinion expressed. Both the city engineer and his assistants are appointed under the civil service law, after passing a competitive examination, and hold office during good behavior.

G. S. Webster, Philadelphia, Pa.—The same general plan prevails, and has been highly satisfactory.

The balance of the paper was as follows:

It would appear that there is considerable diversity of opinion among city engineers as to the best method of making selections for the office, and the authors of this paper desire to state here very emphatically that they have no panacea to present as an unfailing cure for all the ills the engineer and public are heir to in this matter. We have called attention to the ills, and in addition we wish merely to lay down a few principles which we think should help guide the steps of progress in this matter.

First of all, every one can agree to the principle that the city engineer should be selected and retained in office for merit alone. Political affinity should not be taken into account in the slightest degree. The only question at all debatable is how to bring this about.

To place the office under civil service regulations will naturally occur to the thinker on this subject, but it seems evident that this method in its usual form can only be adopted by those cities large enough to maintain a competent civil service commission without finding the expense a serious draft. Moreover, there are so many qualifications for a city engineer which cannot be properly taken into account in any examinations that there is room for serious doubt whether such responsible positions cannot be filled by direct appointment by some intelligent and honest appointing power. Even where civil service regulations are adopted for selecting the city engineer the appointing power should be allowed to give very great weight to those qualifications which cannot be determined by examinations.

In the majority of cities, and especially not of very large size, it seems probable that the city engineer must, at least for a long time to come, continue to be selected by means very similar to those now in use. Any of these means, whether by election or by appointment by mayor, council, or board of public works, is capable of giving most excellent results if administered on the basis of appointment for merit alone, and does in some cases give excellent results. Any of these means, on the other hand, is subject to most deplorable abuses when not administered on the basis of merit.

The question is, then, how to make the consideration of merit the important thing, no matter what method of appointment is adopted. It would seem in the first place, that the law ought carefully to specify the qualifications for the office. This is not the case in Iowa, and our law should be amended. Of course, it would doubtless be possible to evade legal requirements, but the fact that such requirements exist would help. The law should specify that the appointee should be a civil engineer of a certain training (not necessarily school training), and of a certain number of years' experience, and that he should have a recognized high professional standing. If we ever succeed in getting our State License Law for Engineers, a state license should be one of the requirements. Could not the law require that the professional standing of the appointee be certified by a temporary board, one at least to be a civil engineer selected by the president of this society?

In the second place, the tenure of office ought to be during good behavior. Of course, this would carry with it that either the board of public works, the mayor, or the council, should have the power of removal for cause, and they ought not to be so hampered in this respect as to enable an incompetent man to hold on to his position, but the engineer should be given the right to a public hearing before removal, and should have redress in the courts against injustice. Making the tenure of office during good behavior would go very far toward rendering it impossible for men to obtain the office merely as a reward for political services. Moreover, it takes about one of the present terms of office to enable a man to become thoroughly acquainted with the local conditions and requirements of his work, and it is absurd to dispense with his services just as they become most valuable.

In the third place, the appointment of subordinates in the city engineer's department ought in all cases to be on a civil service basis. In cities too small to maintain a civil service commission the examinations could be conducted by the engineer, assisted by other members of an examination board appointed temporarily or permanently

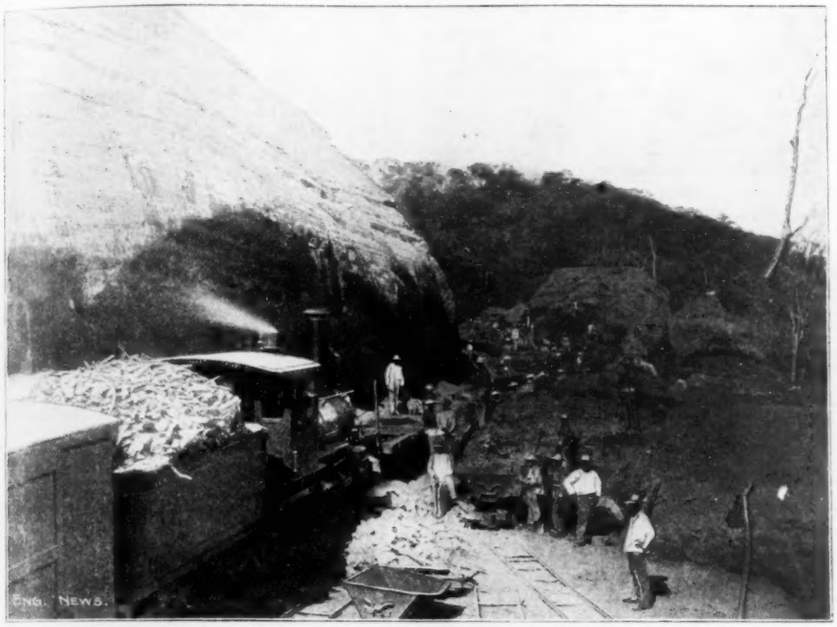


FIG. 3. A CUTTING NEAR THE OLD CRATER LAKE OF ASOSOSCA.

METHODS OF SELECTING CITY ENGINEERS AND THEIR EMPLOYEES IN TWENTY-FIVE AMERICAN CITIES.

City.	Population.	Engineer or corresponding official				Selection of employees.
		Name.	Title.	How selected.	Term.	
Baltimore, Md. ..	508,900	B. T. Fendall.	City Engineer.	Appointed by Mayor.	Four years.	Appointed by Engineer.
Buffalo, N. Y.....	352,400	C. M. Morse.	Deputy Eng'r Comr.	" " Com'r Pub. Wks.	Pleasure of Com'r.	Civil service.
Burlington, Ia. ..	23,200	E. Steece.	City Engineer.	Elected by the people.	Two years.	Appointed by Engineer.
Chicago, Ill.	1,698,600	J. Ericson.	City Engineer.	Civil service.	Good behavior.	Civil service.
Charleston, S. C..	55,800	J. H. Dingle.	City Surveyor.	Elected by the City Council.	Four years.	.....
Clinton, Ia.	22,700	C. P. Chase.	City Engineer.	Elected by the people.	Two years.	Appointed by Engineer.
Colorado Spgs,Colo	22,500	E. W. Case.	City Engineer.	Elected by the people.	Two years.	.....
Columbus, O.	125,600	J. Griggs.	Chief Engineer.	Appointed by Mayor.	Good behavior.	Civil service.
Council Bluffs, Ia.	25,800	S. L. Etnyre.	City Engineer.	Elected by the people.	Two years.	Appointed by Engineer.
Des Moines, Ia....	62,100	J. W. Budd.	City Engineer.	Elected by the people.	Two years.	Appointed by Engineer.
Detroit, Mich.	285,700	S. A. Ferguson.	City Engineer.	Appointed by Com'r Pub. Wks.	Pleasure of Com'r.	Appointed by Com'r.
Kansas City, Mo..	163,800	R. W. Waddell.	City Engineer.	Appointed by Board Pub. Wks.	Pleasure of Board	Appointed by Board.
Lincoln, Neb.	40,200	G. L. Campen.	City Engineer.	Elected by the people.	Two years.	Appointed by Engineer.
Memphis, Tenn...	102,300	J. A. Omberg.	City Engineer.	Appointed by Mayor.	Three years.	Appointed by Engineer.
Milwaukee Wis. .	285,300	C. J. Poetsch.	City Engineer.	Appointed by Mayor.	Three years.	Civil service.
Minneapolis, Minn	202,700	G. W. Sublette.	City Engineer.	Elected by the Council.	Two years.	.....
New Orleans, La..	287,100	W. J. Hardee.	City Engineer.	Elected by the people.	Four years.	.....
Philadelphia, Pa..	1,293,300	G. S. Webster.	Chief Engineer.	Civil service.	Good behavior.	Civil service.
Salt Lake City...	53,500	L. C. Kelsey.	City Engineer.	Appointed by Mayor.	Two years.	Appointed by Engineer.
Omaha, Neb.....	102,600	A. Rosewater.	City Engineer.	Appointed by Mayor.	Three years.	Appointed by Engineer.
Rochester, N. Y...	162,600	E. A. Fisher.	City Engineer.	Appointed by Mayor.	Two years.	.....
St. Paul, Minn....	163,100	L. W. Rundlett.	Com'r of Pub. Wks.	Appointed by Mayor.	Three years.	Appointed by Engineer.
St. Louis, Mo.....	575,200	*Chas. Varrelman.	Street Commissioner.	Appointed by Mayor.	Four years.	Appointed by Board.
San Francisco,Cal.	342,800	C. E. Grunsky.	City Engineer.	Appointed by Board Pub. Wks.	Pleasure of Board.	Civil service.
Sioux City, Ia.....	33,100	J. M. Lewis.	City Engineer.	Elected by the people.	Two years.	Appointed by Engineer.

Summary: Appointed by Mayor, 9; elected by people, 8; appointed by Commissioner of Public Works, 4; elected by city council, 2; civil service, 2; total, 25.

*The Street Commissioner (here) comes nearer corresponding to the City Engineer in other cities.

by the mayor. The engineer should have the right to select from the eligible list, and should also have the power of making removals for cause, after a public hearing given the person removed. Putting the engineer's force on a merit basis will help remove the city engineer's office from politics, for it would then be impossible for any one to demand from him promises of appointments in payment for votes and other assistance. Also it will help the quality of the city engineer's work to have his force permanent, so that when a new city engineer is appointed he may at once have the benefit of the advice and experience of subordinates thoroughly familiar with the local conditions and the routine of the department's work.

The authors do not profess to have worked out all the details satisfactorily, but they are of the opinion that if the three suggestions of rigid legal qualifications of appointees, tenure of office during good behavior, and appointment of subordinates on a civil service basis could be properly elaborated and embodied in our state laws, and a conscientious effort made to enforce the laws, much would be found to have been accomplished toward eliminating the evils, both to the public and to the engineer, resulting from the present conditions.

THE BRIQUETTING OF FLUE DUST, FINE ORE AND FUEL.

For the economical utilization of fine ore, flue dust, and similar fine material, which cannot ordinarily be treated in blast furnaces or smelters in its finely divided state, a process of briquetting is being used in a number of cases. By this process the fine material is consolidated by pressure into small blocks or briquettes which can be reduced in the furnace without waste and without danger of packing into an impermeable mass. With fine iron ores of certain grades and possessing certain chemical properties, this packing has in several cases led to disastrous explosions in the blast furnaces, but the briquetting of the ore itself is not at the present time a commercial possibility. Among the materials which have been successfully treated by this process may be noted the following: flue dust (or very fine ore) from blast furnaces, fine ore obtained by magnetic separation, anthracite and bituminous coal dust, coke and charcoal breeze or dust, copper and lead ore, bauxite, manganese, and slimes from concentrators and electrolytic vats.

While numerous experiments have been made and are still being made, there are comparatively few plants at which the work of briquetting is carried on as a regular commercial process. There is but little literature treating of this particular phase of metallurgical work, and in view of recent evident interest in the matter, we have undertaken a careful inquiry into the process and the results obtained in practical work. From many of the firms who have installed briquetting plants, however, we have information that these plants are not being used regularly, are being used experimentally, or have been in use so short a time that no definite conclusion can be arrived at as to the efficiency of the machinery or the commercial value of the results obtained. The information thus obtained from various reliable resources has been incorporated in the present article, which treats of the general principles involved, the actual practice and experience at different plants, and the character of the machinery and apparatus employed.

In blast furnace work, and especially where fine or soft iron ores are employed, an appreciable proportion of ore is sometimes lost through being blown out by the blast and carried into the flues which lead to the hot blast stoves. To prevent it from entering the stoves, dust chambers or traps are attached to the "downcomer" flues, in which the force of the current of air is reduced, allowing the dust to settle to the bottom, whence it is withdrawn at intervals. This loss has been estimated at 5% to 6% of the charge, representing 30 to 60 tons per day with large modern furnaces. At many large blast furnace plants there are thousands of tons of this dust stored, the accumulation of years, awaiting the introduction of some sufficiently reliable and economical means of utilizing it. It is essential that effective treatment should be obtained at low cost, and whether the adoption of the briquetting process will be warranted in any individual case depends largely upon the amount and value of the ore dust, and the cost of installing and operating the necessary briquetting plant.

In smelter work, however, treating ores of much higher value than iron ore, the briquetting process is of greater commercial importance, and larger expenditures may be made in the drying or other preparation of the dust. Much valuable ore is carried away in the form of fine dust into the tunnels or flues which lead from the roasters to the chimneys. This is caught by riffles or stop walls built across the bottom of the tunnel (Eng. News, Nov. 30, 1899) whence it can be recovered. Besides this waste of lost ore, there are many valuable ores, slimes, concentrates, etc., which are too fine to be charged into the furnaces, but which must be consolidated in some way. The briquetting of coal dust for fuel involves commercial considerations of a different character from those relating to ores, and this matter we shall discuss separately in another part of this article.

Flue dust is first passed through screens which take out the larger pieces of coke, and the size of these pieces of coke is sometimes quite surprising. The coke is delivered into trucks or buggies to be recharged into the furnaces, and the screened dust is carried by conveyors to the storage hoppers. With iron ore this dust contains about 40 to 50% of iron. The machinery must be able to work the dust whether hot or cold, moist or dry. If the dust has been long in storage it will be cold, but it may be delivered almost direct from the furnace, in which case it will have a high temperature. If it is loaded into wooden cars at the furnaces for transportation to the briquetting plant it will often have to be cooled with water, in which case it may be very wet. When wet it is more difficult to add the proper amount of binder, and to get this thoroughly incorporated with the dust.

In a majority of cases the material to be briquetted has to be mixed with a bonding medium which will render it coherent when compacted under pressure, so that the briquettes can be handled without breaking or disintegrating. Materials made up of rough or irregular particles, or containing a proportion of clay, are comparatively easy to treat, but iron ore dust is specially difficult to briquette. It contains no clay or adhesive material and the iron particles are smooth and round, so that when compressed together they do not lock together, as is the case with materials having rougher particles. For this reason the bonding medium is an important feature in the treatment of iron ore flue dust. For this purpose a cream of lime is commonly employed, about 5% of lime being added to the dust. When the mineral dust contains sufficient moisture to slack the lime, the latter may be added to it as a dry powder. Other bonding materials are used to some extent, including refuse molasses, pitch (usually employed for fuel briquettes) and patented compositions. Some of the latter designed for use with iron ore flue dust are found to make stronger briquettes than the lime solution, and also to cause them to break in large pieces with little dust (and consequently little waste) when fractured. The material, however, must be of such a character that it will not produce any harmful effect in the furnace. It is essential that the binding material should be thoroughly incorporated with the dust or other product. The mixing is done by special machinery and the pulp or paste is usually delivered to the briquetting machine by a conveyor. In a paper on "The Briquetting of Minerals," by Mr. Robert Schorr, in the "Engineering and Mining Journal" of Nov. 22, 1902, is the following paragraph respecting this part of the work:

> In briquetting minerals a thorough mixing and kneading is of the first importance. If this is done properly, a comparatively low pressure will suffice to create a good and solid briquette, which after six to eight hours of air drying or after a speedier elimination of the surplus of moisture in hot-air chambers, will be ready for the furnace-charge. A good briquette should permit transportation without excessive breakage or dust a few hours after being made, and it should retain its shape in the furnace until completely fused so as to create as little flue dust as possible. The briquette should be dense, otherwise it will crumble under the influence of bad weather.

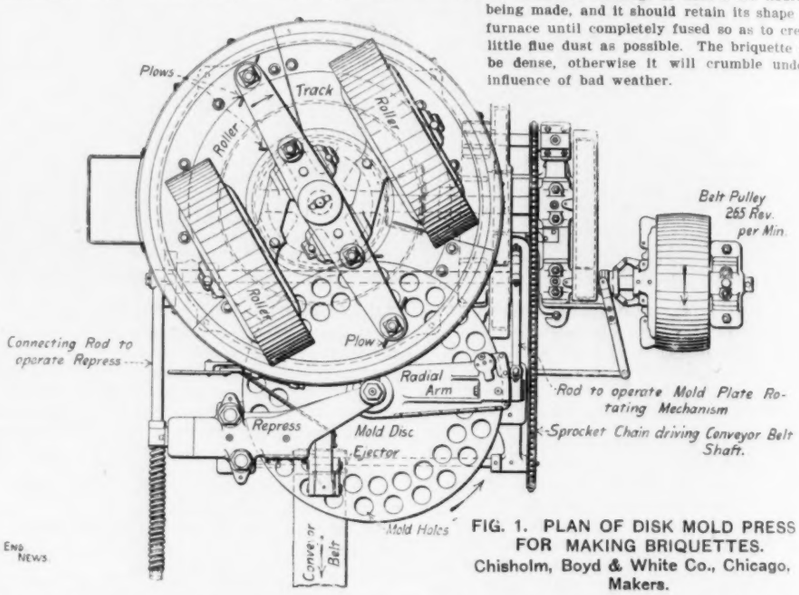


FIG. 1. PLAN OF DISK MOLD PRESS FOR MAKING BRIQUETTES.
Chisholm, Boyd & White Co., Chicago, Makers.

The briquettes are almost invariably of circular form, 3½ or 4 ins. diameter and about 2½ ins. thick. Briquettes of this form and size have been found more satisfactory than rectangular blocks, both in manufacture and in use in the furnace. The diameter tapers slightly so that the briquettes will not stick in the molds. The briquettes are dropped from the molds into wheelbarrows or upon belt conveyors and carried to a storage floor to dry and harden before being charged into the furnace. If it is desired to use the briquettes promptly, or if the storage space is too limited to allow the briquettes to remain for the time required for air drying, they may be loaded into iron cars or trucks which are run into drying ovens heated to a temperature of 200° to 400° F. by waste gases from hot-blast stoves or furnace flues. The hot gases may pass through the oven from end to end (in the opposite direction to the travel of the cars); or they may enter at the bottom, passing up through the loads of briquettes and escaping through openings at the top. The briquettes may be dried in this way in from 6 to 16 hours. With a temperature of 200° to 220° about 15 hours are required. The briquettes may be dried in less time with higher temperatures, but at some plants it has been found that when dried under these conditions they will not stand handling, and will give much more dust and fine stuff when broken than is the case with slow-dried briquettes.

It is hard to state definitely the cost of the briquetting process as very few figures are made public, and the details on which these figures are

based are as a rule not explained. At the Carrie Furnaces, in 1898, the cost was 54 cts. per ton of flue-dust briquettes. At Nelson, B. C., the cost of ore briquettes is about 81½ cts. per ton. More complete details of these costs are given further on. By the manufacturers of briquetting machinery, the cost, including labor and power, the bonding medium, oil and waste, and repairs, is said to be from 50 to 80 cts. per ton of briquette, varying with the conditions at each plant. Some users of the process, however, state that the latter figure is too low as an average for regular work for any length of time. In the article on "The Briquetting of Minerals," by Mr. Robert Schorr, already mentioned, is the following paragraph concerning the matter of cost, but for machines working in regular and continual service for long periods of time the item of repairs would probably be more serious than the latter part of the statement would seem to imply:

As mineral briquetting cannot be effected without considerable wear upon the machinery and without quite appreciable expense in binder, labor and handling, many smelters try to avoid it. The financial question, however, is not as serious as it may first appear, and taking the large output of modern briquetting machines in consideration, the cost for repairs amounts only to a few cents per ton of briquetted material. The total cost depends in the first place on the cost of labor, power and the binder, and in most American smelters it varies between 65 cts. and $1.25 per ton of briquettes.

Only two types of briquetting machines are in any extensive use in this country. These may be distinguished as the disk mold or roller press, made by the Chisholm, Boyd & White Co., of Chicago, and the plunger press, made by the Henry S. Mould Co., of Pittsburg. The development and construction of these machines will be described later. There are altogether probably about 100 briquetting machines of the different types in use, but many (if not the majority) of these are being used experimentally rather than commercially. One small machine of the plunger type is said to be in use in New York for briquetting the sweepings from jewelers' workshops, the briquettes being then melted in an assay furnace.

THE BRIQUETTING OF IRON ORE FLUE DUST.

The first experiments in briquetting fine ores and flue dust in this country were made at the Carrie Furnace, at Rankin, Pa., which is now owned by the Carnegie Steel Co., of the United States Steel Corporation. A press of the disk-mold type was installed at this furnace in 1896, and was operated successfully until the furnace plant was purchased by the Carnegie Steel Co., on May 1, 1898. As the new management did not wish to take up the work of briquetting, the machine was dismantled and stored. It may, however, be again put in service at some future time.

During the time that the briquetting process was in use, there were two blast furnaces of 300 tons capacity each. These used about 30% Mesabi range ore, 20% hard ore, and 50% old range ore. About 2% of the ore charged was carried away as dust and recovered for briquetting, the dust recovered in 24 hours being about 40 to 45 tons, while about 45 tons of briquettes were made in a run of 12 hours. The briquettes dropped from the machine directly into wheelbarrows, and were then dumped on the storage floor. After about 48 hours drying in the open air, the briquettes were shoveled into wheelbarrows, the loads being weighed, and then charged into the furnaces. At one time the briquettes represented about 4½% of the charge, while at another time they represented 2%; both plans worked satisfactorily. The mixture used in 1898 was as follows: Flue dust, 94%; lime, 3%; clay, 3%. The cost per ton of briquettes not dried was approximately as follows: Labor, 29 cts.; mixing material, 16.5 cts.; repairs to machinery, 8.5 cts.; total, 54 cts. Comparative analyses of the "downcomer" dust and the briquettes made in 1898 are given in the accompanying table.

Table Giving Comparative Analyses of "Downcomer" Dust and Briquettes.

	Dust, per cent.	Briquettes, per cent.
Water	8.95	13.35
Silicon	5.33	7.35
Alumina	2.00	2.20
Iron	49.86	45.03
Manganese	0.22	0.14
Lime	1.71	2.59
Magnesia	0.63	0.62
Phosphorus	0.033	0.028
Sulphur	0.143	0.204
Insoluble	0.628	...
Organic and volatile	8.41	5.92

The Illinois Steel Co. has carried on the work of briquetting flue dust since 1896, and has installed kilns or ovens for drying and hardening the briquettes before they are charged into the blast furnace. The company commenced its experiments in 1896 by installing at its South Chicago works a Boyd pressed-brick machine, of the vertical plunger type, modified for pressing flue dust. This machine was operated until 1897, when its use was abandoned, and a briquetting press of the disk type installed in its place. The company operated this machine for four years, and in 1901 installed a second disk machine and the necessary auxiliary mixing apparatus. Both of these are now in regular operation for the briquetting of common iron ore flue dust, and the plant has been in practically continuous operation for 12 months at a time, working days, nights and Sundays. The briquettes are 3⅛ ins. diameter and 2½ ins. thick, and they weigh about 2½ lbs. each. The capacity of the two mills is about 100 tons per day of 20 hours. The flue dust consists of fine powdered ore mixed with coke and limestone dust, and is carried from the furnaces to the briquetting plant in railway cars. It is first screened, to remove the large pieces of coke which are re-charged into the furnace. Screw conveyors deliver the screened dust to a belt conveyor which carries it up to the storage bins, from which it is fed to a mixing machine, in which a patented bonding material is added. The proportions of this liquid is varied by the men in charge according as the dust is hot or cold, wet or dry. The mixture is then fed through a chute into the face of the briquette machine.

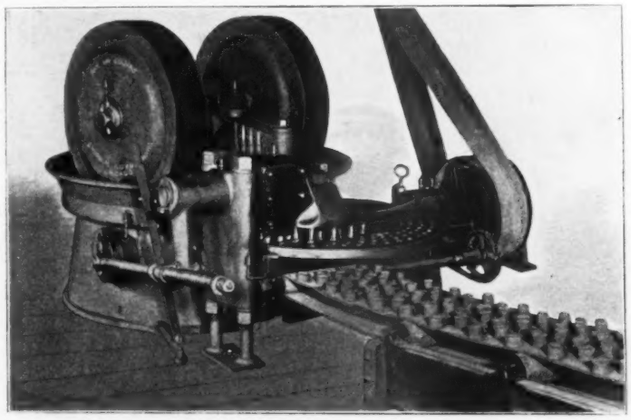


FIG. 2. BRIQUETTING MACHINE OF THE DISK-MOLD TYPE.

The briquettes are ejected three at a time and fall upon a belt conveyor, from the end of which boys remove them and pile them in small iron cars having perforated sides. These cars are run into long drying ovens, which are continually full, the cars being pushed in at one end and withdrawn from the other. In these ovens or tunnels a temperature of about 200° to 212° F. is maintained by means of waste furnace gases, which flow in the opposite direction to the travel of the cars. Each car remains about 15 hours in the oven, as it has been found that briquettes dried more rapidly by higher temperatures are more easily broken. The briquettes are then loaded into small cars for transportation to the blast furnaces. Practically all the dust now produced by the ten furnaces is briquetted by this plant, but the briquettes, of course, form but a small proportion of the ore charge of the furnaces.

Early in 1901 the Cambria Steel Co., of Johnstown, Pa., installed an improved press of the disk-mold type, together with auxiliary machinery for mixing the flue dust with lime and water to form a paste. The drying ovens were built by the steel company and are heated by waste gases passing from the boilers to the chimney. This plant has been in operation for about 15 months. The bricks are 3¼ ins. diameter and 2¼ ins. thick, and weigh 1⅝ to 1⅞ lbs. The Warwick Iron & Steel Co. and the Jones & Laughlin Steel Co. have recently installed machines of the plunger type for experimental purposes. The Pennsylvania Steel Co. is preparing for some experimental work in the briquetting of flue dust and also of fine ore which is obtained by the crushing and magnetic separation of Cornwall (Pa.) ore. This ore normally contains only about 40% of iron, which is too low for economical reduction in a blast furnace; but the fine ore obtained by separation contains about 66 to 70% of iron. Two machines, of different types, have been installed, but they have not yet been put in service.

In this connection we give the following extracts from a paper on "The Briquetting of Iron Flue Dust," in the "Iron Age" of Dec. 11, which paper was written by Mr. R. M. Hale, Superintendent of the briquetting plant at the South Chicago works of the Illinois Steel Co.:

The cardinal principles of successful briquetting are: (1) Thorough amalgamation of binding materials with the flue dust; (2) thorough pugging with pressure; (3) additional pressure after the material has been forced into the molds; (4) slow but thorough drying.

In the plant under consideration, part of the dust is delivered from the dust catchers into buggies and hauled to a cable incline, at the top of which it is delivered into a hopper, fed into hexagonal revolving screens, and deposited in a larger hopper below. The dust so delivered is very hot. Some dust comes to the briquette plant in railway cars, being delivered directly from the dust catchers into cars. The dust so delivered is generally cold and wet, it not being found advisable to ship the dust hot in ordinary railway cars. The dust is unloaded from the cars and delivered to a large storage bin at the briquette plant. From this bin it is carried by an inclined belt conveyor and delivered through suitable spouts to another hexagonal revolving screen, and the fine dust is deposited in the hopper below. These screens are of the usual revolving type, having an elliptical mesh ¾ × ⅝-in., and no material fine enough to pass through this mesh will do any harm to the machinery beyond. The coke obtained from screening the flue dust is put back into the furnace, thus obtaining a very valuable economy.

The two screens are located over the same hopper, the hot dust being separated from the cold dust by a partition. At the bottom of the hopper are two automatic feeders which feed the hot and cold dust into the conveyor mixer, where the hot dust absorbs all or a portion of the moisture from the cold dust. These feeders are adjustable, so that the feed can be changed readily according to the heat and moisture in the dust, thus giving a resultant dust of a nearly uniform character.

The conveyor mixer consists of a long U-shaped trough of sheet steel, having a 4-in. square shaft running horizontally through it, upon which shaft are bolted blades 3 ins. apart and at an angle of 30° to the shaft. As these blades revolve, a thorough mixing of the dust is obtained and at the same time the dust is moved forward through the mixer. From this conveyor mixer the dust is delivered onto an incline-belt conveyor and carried up to a large storage hopper above. On the bottom of this hopper are two more automatic feeders, one for each press. Each of these feeds into a conveyor mixer, into which is also fed the bonding agent. It is here that the dust and the bond are first amalgamated. The bonding agent, which consists of lime, soda ash and salt (a patented bond), is dumped into a small skip hoist from the main floor of the plant and carried up to a tank on the upper floor. First a certain amount of salt and soda ash, previously determined, is dumped into the tank on the top floor which contains water; this mixture is then allowed to boil for about 20 minutes, after which operation lime is dumped into the boiling brine and allowed to slake.

The tanks are 4 ft. in diameter and 4 ft. high, having a vertical shaft through the center, carrying paddles. The shaft and paddles are given a rotary motion by means of suitable gearing, thus obtaining constant agitation of the mixture in the tank and preventing any settlement. The lime, salt and soda ash are allowed to remain in the upper tank until the whole becomes of the same consistency, the thickness of which depends upon the amount of lime added. It is then lowered to a tank on the floor below and from there it is allowed to run into the same conveyor mixer as the dust, through a 2½-in. brass gate valve. By means of this gate valve the

amount of bond can be regulated at will according to the possible variation in the dust.

From this mixer the mixed dust and bond falls through a spout into the pan of the mill or press. This pan is about 7 ft. diameter, and through the center extends a vertical shaft carrying two large rollers, each weighing 6,000 lbs., and a plow beam carrying four plows. By this means the more thorough amalgamation of the bonding material with the flue dust is accomplished. The plows being set at an angle with the plow beam throw the material directly in the path of the rollers, where it is rolled down under a pressure of 6,000 lbs. and immediately plowed up again by the plows following the rollers. The rotary motion of the rollers and plows give to the material a creeping motion so that it gradually travels along the circular path of the rollers to the point of exit from the pan.

Into a section of the press pan extends a portion of the horizontal circular mold disk. This is 5 ft. in diameter by 2½ ins. thick, its center being outside of the press pan. In this disk are 72 holes, in three rows of 24 each; these holes are 3 ins. in diameter at the top and 3¼ ins. at the bottom. As the holes pass around through the press pan they are filled with flue dust under pressure of the rollers, they then pass out of the press pan and are brought under a set of repress plungers where additional pressure is given to the briquettes. (The machines used in making briquettes are described more in detail further on in this article.—Ed.) From the repress, the briquettes

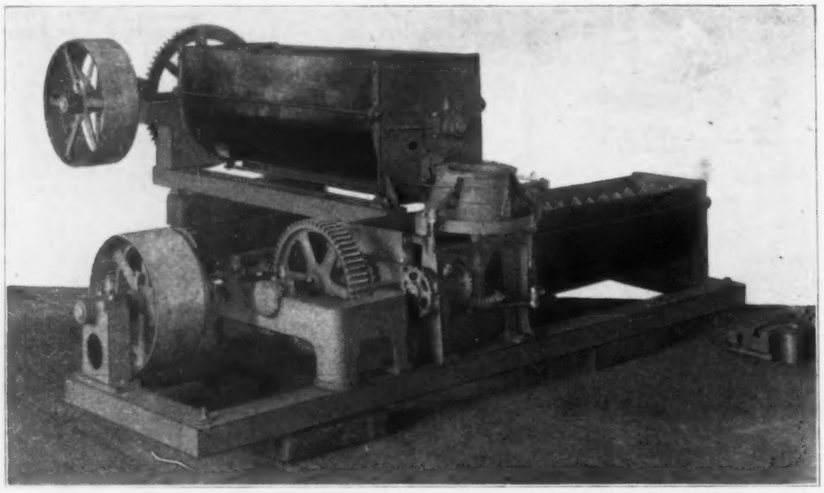


FIG. 3. APPARATUS FOR MIXING FLUE DUST WITH BONDING MATERIAL.
Chisholm, Boyd & White Co., Chicago, Makers.

are passed around with the disk until they come under the ejector arm, where they are ejected and drop on a conveyor belt. This belt carries the briquettes some 12 ft. from the press, and they are loaded into cars by boys. These cars move in a direction at right angles to the travel of the belt and after being loaded they pass on to a transfer car, which transfers them to the drying-over tracks.

The two drying ovens are 200 ft. long, and each oven has two tracks. Each track holds 27 cars and is always kept full, so that as a car of green briquettes is pushed in at one end a car of dry briquettes comes out at the other end. These cars of dry briquettes are put on another transfer car and transferred to the unloading track where they are unloaded and then pass on up the same track to the press, to be loaded again with green briquettes. The dry briquettes are shoveled into buggies and put into the furnaces, being sent up in the old-style elevator or in a skip hoist where the furnaces are so equipped.

Flue dust is a specially hard material to work. It has no plasticity, and its action on all working parts of machinery is like powdered emery, it grinds and cuts everything with which it comes in contact. The dry dust blows with the slightest wind and is thus carried and lodged on all parts of the machinery. Eternal vigilance is a prime requisite in keeping such a plant in good running order.

Aside from the purely mechanical questions involved in designing and operating such a plant, the three most important points are as follows: (1) The bonding agent; (2) the amount of pressure and pugging the green briquettes receive; (3) the drying ovens. With these three questions unsuccessfully solved the mechanical superiority of your plant will not enable you to make successful briquettes. On the other hand, with these three points successfully solved and the mechanical standard of the plant low, you cannot make briquettes economically.

Lime is the most natural bonding agent to which all blast-furnace men first turn their attention. They want lime in the furnace, and if the percentage of briquettes in the burden is large enough the lime in them can be reckoned and a proportionate decrease in the amount of limestone used is thus obtained. The function of lime in the briquettie is three-fold: (1) To give hardness to the briquette; (2) to make the material more plastic so that it can be worked to better advantage in the press, and (3) to make the briquette self-fluxing. But it was found that lime alone would not give sufficient hardness to the briquettes to enable them to withstand the severe handling to which of necessity they must be subjected. Therefore some other bonding agent was sought which would increase the hardness of the briquette and yet which would not have chemical properties objectionable in the furnace. The consideration of the cost of any additional bonding agent was one of considerable moment.

After some experimenting it was found that a good grade of commercial salt would increase the hardness of the briquettes. But with the added percentage of salt the cost was increased and therefore it was decided to sacrifice, to some extent, the second function of lime in order to maintain the total percentage of the bonding agent the same and thus keep the cost nearly constant, lime and salt being nearly the same price per ton. For instance, 6% of lime was first added and then 2% of salt; this made the cost too high, so the lime was cut down to 4% and the salt remained at 2%. The sacrifice of the second function of the lime was made up in another way, which will be shown later.

The lime and salt briquettes, while they were quite hard at first, were found after a time to absorb moisture from the atmosphere so that they crumbled to dust again, thus rendering the briquettes practically useless for commercial purposes. Commercial salt contains calcium chloride ($Ca\ Cl_2$) and this calcium chloride is the moisture-absorbing property of salt. Therefore it is desirable to get rid of it. Sodium carbonate or commercial soda ash added to calcium chloride produced sodium chloride and calcium carbonate, the latter an insoluble substance

$$Ca\ Cl_2 + Na_2\ Co_3 = 2\ Na\ Cl + Ca\ Co_3.$$

Briquettes made of salt treated with soda ash were found to be sufficiently hard and non-absorptive to stand both the handling and the weather, but the cost was high. The percentages were therefore again changed, this time to 2½% lime and 2½% salt and soda ash, thereby maintaining about the same total cost. Probably the best briquettes were made with from 5 to 10% of salt and soda ash, but this was accomplished by the total sacrifice of the second and third functions of lime and at an increase in the percentage of chlorine put into the furnace, which was not deemed a wise procedure. Salt has another function to perform, and that is in relation to the character of the break. Pure lime briquettes crumbled into dust when broken; with the addition of salt, the briquettes have a clean break and produce very little dust.

A thin milk of lime gives no plasticity to the flue dust, the plasticity of the mixture increases in proportion to the thickness of the solution of slaked lime. Lime slaked in the ordinary manner and allowed to settle in settling tanks or pans becomes thicker the longer it is allowed to remain at rest, and after several days it becomes of the consistency of soft putty. Briquettes made of lime of such a consistency are very good when green, but it was found that the extra expense incidental in handling lime thus made, and in providing storage for so large an amount of lime, more than offset the advantage gained. Therefore this method was abandoned and the lime used as it was slaked. A very good thick cream of lime (about the consistency of soft butter) could be obtained in the ordinary lime tanks, in the space of time allowed, and considering all questions involved, for all practical purposes this solution was found to be the most economical.

To compensate for the loss of the second function of lime, that is plasticity, attention was diverted from the chemical to the mechanical side of the question. This leads to the consideration of the second point made, the amount of pressure and pugging the green briquettes receive. Pressure alone on flue dust will not make a good briquette. It is essential that the material should be pugged thoroughly to get the binder worked in and incorporated with the flue dust. This pugging process increases the plasticity of the material. A thin solution can be incorporated with the dust more quickly than a thick putty solution. The time occupied by the dust in traveling through the mixer and press was so short that with a thick binder the solution was not properly amalgamated. Hence, the return to the thinner solution.

The briquettes when made did not seem to be very compact, the amount of travel of the repress plungers was not sufficient to compress the material enough to eliminate the small air spaces between the small particles of dust. The travel of the plungers was therefore increased and at the same time the pressure on the briquettes was increased. Thus a briquette was obtained of sufficient hardness to compensate for the loss in plasticity.

The third point, the drying ovens, then received attention. As stated before, the best briquettes were made with 5 to 10% of salt. But these briquettes were air dried, being allowed to remain in the sun during warm weather for three or four days. They were considered as the standard of excellence as to hardness, and were rated as 100 in that scale for the matter of comparison. These briquettes could be thrown with considerable force against a concrete wall and simply have their edges broken.

In this climate, air drying could not be depended upon and the point to be made was to obtain a drying oven corresponding as nearly as possible to good atmospheric conditions. The temperature of the air was not high, but the amount of air was large. Hence a large volume of air of a moderate temperature was desired in the ovens. Briquettes submitted to a high temperature at the start have a hard shell formed on the outside, varying in thickness from ⅛-in. to ½-in. This shell, while not strong enough to withstand the handling, was a great disadvantage, as it prevented the interior of the briquettes from drying.

The green briquettes should be submitted to a low temperature at the start and the heat should be gradually increased as they progress through the oven. In this way the moisture is drawn from the interior of the briquettes to the surface and is then absorbed by the large volume of air passing over them. Properly dried briquettes show no shell on the outside; they are of the same hardness all through. The oxygen of the air acts with the salt in producing an oxide of iron, and this rusts the particles of the briquette together. A good briquette shows little rust spots inside and out, and has a brownish red appearance.

As a matter of economy, waste gas from the furnace, after passing through the stoves, is used for drying. There is very little free oxygen in this gas, hence the gas was diluted by the admission of air. By a long series of experiments, a briquette of about the hardness of 85% in the scale was obtained with a temperature of 125° at the entrance of the oven and 200° at the end, using as a binder 4 to 5% of lime and 1 to 2% salt, corrected with soda ash. These briquettes would stand the handling nicely and from all points were considered a success.

The cost of briquetting varies with the mechanical standard of the plant and the amount of tonnage handled. It would be difficult to make any specific statement which would fairly represent the progress of briquetting in this respect, but it is safe to say that in a plant handling a large tonnage the cost can be reduced to a remarkably low figure. In fact in such a plant it would be practical to transport the dust some distance from the furnaces to the briquette plant, thereby increasing the field of usefulness of such a plant. The binder used at present is a large factor in the cost per ton, averaging about one-third of the total, and any advantage which can be gained tending to reduce this item, is a matter worthy of attention. A binder which would cost less than 5 cts. per ton of briquettes and which would at the same time fulfil all the other functions of a binder, would be an enormous factor towards determining the final success of the briquetting proposition.

The value of flue-dust briquettes is reckoned principally from the amount of iron contained in them. Taking into consideration this point and the saving derived from the reduction of fine material in the furnace burden, it is safe to say that the use of flue-dust briquettes as an economical factor in the operation of blast furnaces is a matter worth serious consideration.

THE BRIQUETTING OF VALUABLE ORES.

One great field for the development in the use of machinery for briquetting is in connection with smelting and refining works, where the value of the material thus saved and utilized is very much greater than that of iron ore dust, as already noted. This valuable material includes flue dust, fine ores, calcines, concentrates, slimes and other "fines" of copper ores and the ores of precious metals. The Anaconda Copper Mining Co., of

Anaconda, Mont., has installed both the disk and the plunger types of machines, but we are informed that the work so far done has been entirely of an experimental character. The conditions there are somewhat different from the ordinary flue-dust briquetting proposition, as there is a large amount of fine slimes and concentrates to be dealt with. The drying of the briquettes has also something to do with the preliminary making of them, and we are informed that it is probable that neither of the machines will be found thoroughly adapted to the company's special kind of work. In this event the engineers may have to design a machine to meet the particular requirements, since the local conditions are always a determining factor in this class of work.

The Bingham Copper & Gold Mining Co., of West Jordan, Utah, informs us that it has one of the plunger type of briquetting presses, making about 60 tons of flue dust into briquettes in eight hours. The contents of the ore are 60% sulphides and 40% silicious. The briquettes are 3½ ins. diameter and 2½ ins. thick, weighing about 2 lbs., and are charged directly into the furnace. The machine has been in operation for about a year, with good efficiency and light repairs. The Old Dominion Copper Mining & Smelting Co., of Globe, Ariz., has also a single machine of the plunger type for briquetting flue dust and fine coke, but it has not been in continuous service, so that no results can be given. The briquettes are 4½ ins. diameter and 2 ins. thick, weighing about 2 lbs. The dust is delivered upon a Robins belt conveyor, and an additional slacking tank is used, but there is no drying apparatus.

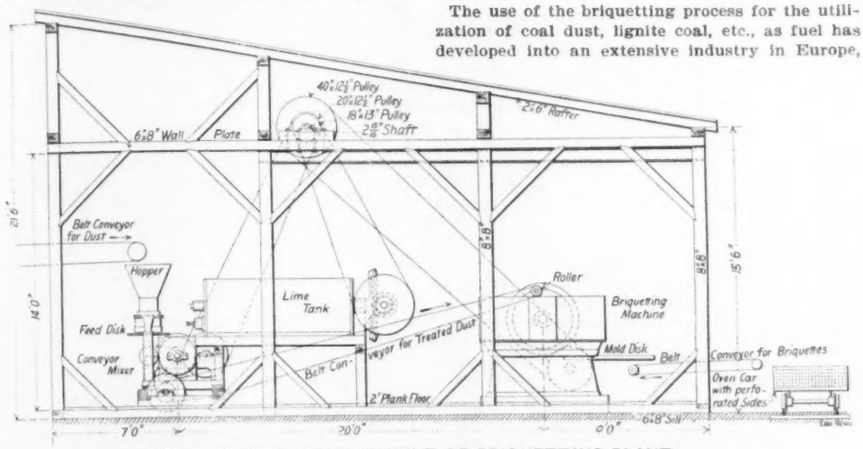


FIG. 4. GENERAL ARRANGEMENT OF BRIQUETTING PLANT.

The following statements have been furnished us respectively by (A) the Granby Consolidated Mining, Smelting & Power Co., of Grand Forks, B. C.; (B) the Hall Mining & Smelting Co., of Nelson, B. C., and (C) the Tacoma Smelting Co., of Tacoma, Wash.:

(A) In regard to briquetting material at our smelter, we have one three-plunger Mould briquetting press which is used to briquette flue dust exclusively from our four copper blast furnaces. We are treating 1,500 tons of ore per day and make about 30 tons of flue dust. This machine is giving us entire satisfaction and has been in use now about six months. One peculiarity is that our flue dust contains enough slack lime to form binding material, and we simply mix the flue dust in a trough with a little water by means of two conveyors having arms which push the material forward as it is mixed to a belt which carries it to the machine. The briquettes weigh about 2¼ lbs.

(B) We have in use one of Mould's briquetting presses of the smaller size, 50 tons capacity. We briquette with it the product of a mechanical roaster, the ore roasted varying considerably from pyrites to base galena and a mixture thereof. When in good working order, we find it possible to briquette about five tons per hour, but the average capacity for ten hours' work is from 35 to 40 tons, owing to the necessity of frequently overhauling, cleaning, etc. The machine has been in use for about 18 months, and is fairly satisfactory as to efficiency. The ore is mixed with about 6% lime as a binder in an ordinary mixing trough, and briquettes are not dried in ovens but dumped into a pile on a floor. This entails considerable abrasion and breaking, but is more economical as to handling, and suits our purposes. The briquettes vary in weight from 3 to 4½ lbs. From the storage floor they are taken to the furnace as required, generally 24 to 36 hours after mixing. We divide our cost into four items only, and it may be said to average as follows per ton: 38½ cts. for labor, 30½ cts. for lime, 1 ct. for other supplies, and 11½ cts. for maintenance of plant. The lime cost given here is an average over about 15 months, and appears to be rather high for some reason. Of late it has been costing but 16 cts. per ton, but this is dependent upon the material to be briquetted. From 3 to 7% of lime is used. The lime costs $10 per ton and is of excellent quality.

(C) We have one briquetting machine, made by the Chisholm, Boyd & White Co. It treats the product of three mechanical roasting furnaces, principally fine concentrates; and also whatever flue dust is recovered from our dust chambers. The quantity of material briquetted daily is 150 to 160 tons in 22 hours, two shifts of 11 hours each. The machine is satisfactory as to efficiency, and we figure that 2 cts. per ton of material treated is ample to cover the item of repairs. The machine has been in continuous use since April, 1899. The roasted product is taken direct from the roasters to the feed hopper of the machine by a system of conveyors and elevators, and is there mixed by means of the lime slaker and mixer furnished with the machine. The briquettes are 3 ins. in diameter, 2½ ins. thick. Their weight averages about 3 lbs., but varies slightly, according to the nature of the material.

THE BRIQUETTING OF FUEL.

The use of the briquetting process for the utilization of coal dust, lignite coal, etc., as fuel has developed into an extensive industry in Europe, particularly in Germany, Belgium and France. In this country, however, the price of coal under normal conditions is so low, and the price of pitch (commonly used as a binder) is so high, that the manufacture of fuel briquettes has not been commercially profitable. Boiler grates and furnace appliances have been developed for the satisfactory use of cheap run-of-mine coal, and for special treatment it would probably be cheaper to pulverize the coal into a fine dust and burn it with an air jet, than to take the dust and compress it into blocks of fuel. As far as making the briquettes is concerned, that is attended with apparently little difficulty, except in the case of peat, whose fibrous character and large proportion of moisture require an enormous pressure (and very heavy and expensive machinery) for successful treatment. But the cost of manufacture would hardly warrant the introduction of the process, since it would be difficult to find a market for the product. The use of fuel briquettes in Germany was described in our issue of Jan. 1.

The Chisholm, Boyd & White Co., a few years ago purchased the drawings of a Belgian machine for making small briquettes or "eggettes" from coal dust, and a machine was built which is still in the company's shops, having been used only for experimental work. This machine has two heavy rollers on parallel shafts, with gearing on the center of the faces of the rollers. The rollers are in contact and have rows of hemispherical recesses on the smooth part of the face on each side of the gear. The material is fed in from above, compressed into the cups formed by holes on the two rollers coming together, and the blocks thus made drop out from below as the faces of the rollers part contact.

Coal briquettes made in the form of eggs, and termed "eggette" coal, were experimented with in this country about ten years ago by the Fuel Patents Co., of Philadelphia. Five or six plants were at one time in operation, and satisfactory efficiency results were obtained on tests with different grades of coal, but the business was not a success commercially. The reasons for this were the low price of coal, the high price of tar used as a binder, and the fact that several of the parties interested had more important business claiming their attention. Mr. Max Nirdlinger, General Manager of the company, and who had practical charge of the business, died some time ago, and nothing has since been done. Two of the briquetting machines are now in the possession of Mr. S. F. Nixon, of Philadelphia, President of the company. The press consisted of a pair of rolls with faces in contact, and having pockets or recesses in these faces. The prepared material was fed in from above and compressed in the pockets, from which they fell in egg-shaped blocks. The presses were originally used in the cement business by Mr. R. W. Lesley, M. Am. Soc. C. E., of Philadelphia, and were employed for a number of years in the preparation of the raw material for the kilns. After the rotary-kiln process came into use, the presses were abandoned, owing to the change in the process and to the advance in the price of coal tar, which was due to the introduction of water gas.

Briquettes of lignite have recently been experimented with to a limited extent as fuel for locomotives on the Minneapolis, St. Paul & Sault Ste. Marie Ry., which road has formerly tried the ordinary lignite coal, but without satisfactory results. Owing to the fact that the briquettes were made by hand in a crude manner, only about a ton of the briquetted fuel was available. The experiment was considered satisfactory as far as it went, but nothing definite can be said as yet concerning the practicability of this fuel. No changes were made in the firebox or smokebox of the engine. The briquettes were about half the size of building bricks, and were made from lignite from mines in North Dakota, owned by Mr. W. D. Washburn, of Minneapolis, President of the Bismarck, Washburn & Great Falls Ry. Mr. Washburn informs us that upon the strength of this and other tests he expects to erect a briquetting plant near the mines, but has not yet decided whether to use machinery of American or German design. Coal-dust briquettes are extensively used for fuel on French, Belgian and German railways, and are, as a rule, rectangular blocks.

BRIQUETTING MACHINERY.

Having now described the general purposes and operations of the briquetting process, and given particulars of its use in various cases, we may turn to the development and construction of the machinery employed. About eight years ago, Mr. B. C. White, who was then President and Mechanical Engineer of the Chisholm, Boyd & White Co., of Chicago, manufacturing pressed-brick machinery, had his attention turned to the design of machinery for consolidating fine ore and dust of the class above mentioned into blocks or briquettes which could be conveniently charged into the furnaces and thus effect a considerable saving from loss or waste. A smelting company purchased a Boyd brick press for compressing its fine material into bricks for the furnace, but it was found that while the machine was a success in working clay, it was not a success when applied to flue dust, fine ore, concentrates, or other non-elastic material. It also appeared that blocks of the size and shape of bricks were not suitable for furnace work. The experiments with this and other similar machines led him to the design of a special form of press for making small blocks or "briquettes" from flue dust, fine ore, etc.

The first type of special machine was brought out in 1896, and was designed to be both a mixing and pressing machine, with the idea of getting rid of the auxiliary apparatus for mixing the dust into a paste with water and the necessary binding medium to make it coherent. This first machine was sold to the Guggenheim Smelting Co., and remained in use for several years. The principle was that the rollers of a pan or Chilean mill forced the material into holes in a horizontal rotating mold disk. The design was improved from time to time, and the machine was supplemented in 1897 by the attachment of a re-pressing

device. This form of the machine is known as the White mineral press. In 1898, Mr. White went to Europe to investigate foreign practice in briquetting machinery, and shortly after his return he severed his connection with the Chisholm, Boyd & White Co. At the same time he sold to them the right to manufacture the machines under the patents taken out in his name. In 1899, he designed a modified type of machine, somewhat on the lines of the original, but having the pressing independent of the mixing, although all the apparatus was still

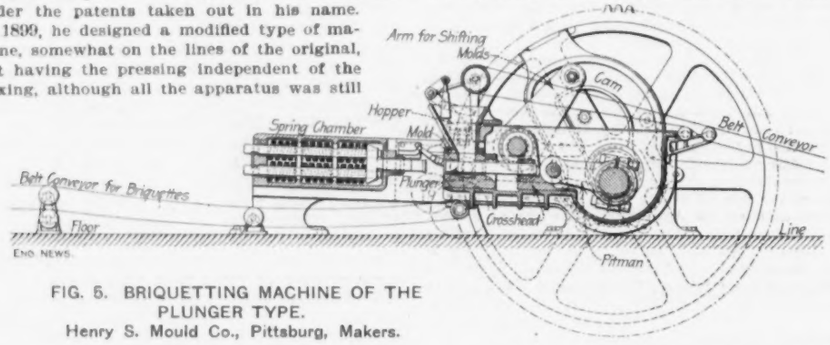


FIG. 5. BRIQUETTING MACHINE OF THE PLUNGER TYPE.
Henry S. Mould Co., Pittsburg, Makers.

combined in the machine. Only two of these were built, however.

Mr. White then turned his attention towards the design of an entirely new type of briquetting machine, using horizontal reciprocating plungers and dispensing entirely with the Chilean mill. In 1899, he brought out his new machine, and became associated with the Henry S. Mould Co., of Pittsburg, which now has the sole right for its manufacture. The machine was further improved in 1900, and is known as the White briquetting press. The above outline of the history of the two types of briquetting machines now in use explains the fact (which has given rise to considerable confusion) that two different types of machines made by different manufacturers, are both known as "White" machines. We will now turn our attention more particularly to the mechanical construction of the machines.

DISK MOLD MACHINE.

The original machine is designed on the principle of the Chilean or pan mill, the molds being formed in a rotating horizontal disk which intersects the roller path in the bottom of the pan. The two heavy rollers revolving on their own axes and traveling around a circular path were at first intended to mix the ore or dust with the lime solution previously added to it to act as a binder. This combination of processes, however, was not entirely satisfactory, and the mixing is now done by separate and independent apparatus, the rollers serving to complete the mixing and to force the moist mixture into the molds. Plows or scrapers attached to the arms between the rollers keep the material within the roller path, this path being formed by a stationary chilled cast-iron track-plate, broken at one point to allow the mold-plate to enter the path. The construction is shown in Fig. 1.

The rollers are 4 ft. diameter, 12 ins. wide on the face, and weigh about 5,000 lbs. or 6,000 lbs. each. They have cast-iron hubs or centers, with removable chilled cast-iron rings secured by three bolted attachments. These attachments are so made as to allow of the expansion and contraction of the rings, which sometimes work in hot material. The mold-plate is of cast iron, as hard as can be used and still allow of machining. Its life ranges from four to ten months, or even longer in some cases. It is 5 ft. diameter and about 2½ ins. thick. In it are two or more concentric rows of mold holes, which are bored out to a diameter of 4 ins. at the top and 4¼ ins. at the bottom. These are near the outer edge of the plate, and there are 24 holes in each row. As the plate revolves, the holes lying within the path of the rollers are filled with the mixture and subjected to the pressure due to the weight of the rollers. That part of the mold-plate which lies within the roller path rests on a heavy bed formed in the frame of the machine, and faced by a planed steel plate on which the mold-plate slides. The plate continuing to revolve, the holes thus filled pass outside the pan and come over a conveyor belt, and the briquettes are then ejected by vertical plungers so as to drop upon the belt.

The pan is driven by gearing in the usual way, and a connecting rod from one of the gear-shafts operates the mechanism for rotating the mold-plate or disk. The mechanism consists of an arm extending radially across the disk, and pivoted to a center corresponding with the center of the disk. At the outer or free end of the arm is a crank arm to which the connecting rod above mentioned is attached. When the crank arm is on its forward center a plug or pawl pin on the radial arm drops down and engages with one of the mold holes in the disk, and as the crank travels towards its back center, the disk is moved the required distance, which is 15°, or 1-24th of a revolution. The plug is then lifted from the hole, and the further movement of the crank returns the radial arm to its former position, ready for another stroke. The movement of the disk takes place at a time when neither of the rollers stands upon it.

It soon appeared from practical experience that the pressure due to the rollers passing over the molds was not sufficient to make the briquette dense enough to stand even ordinary handling. Although the rollers weigh 5,000 lbs. each (or 6,000 lbs. in the older machines), the pressure on the mold is reduced by the fact that the roller is not in direct contact with the mold-plates, a bed of the pulp or mass about 1 in. to 3 ins. thick being interposed, and the roller having a certain vertical play. A re-pressing device was therefore added, consisting of a heavy toggle press at the side of the pan, so that the mold-disk passes between the jaws. The pressure can be varied by inserting toggle blocks of different lengths, thus increasing or decreasing the downward travel of the plungers.

This toggle is driven from a crank-disk on the end of the main gear shaft extending under the pan; a connecting rod leading from the crank pin to an arm on the end of the toggle shaft. This shaft has a semicircular groove along its face, in which fits a roller, the projecting face of the roller lying in a groove on a block called (from its shape) the "book." The rounded lower face of this "book" works in a groove on the top of the crosshead, to the bottom of which are attached the plungers which enter the top of the mold holes and press the briquettes. This arrangement only acts downward. To raise the crosshead there is an iron bar like an inverted L attached to the side of the crosshead, the horizontal leg extending over the shaft so as to engage with a cam projection. On the outer end of the toggle shaft is another arm carrying a vertical lever to which are attached the ejecting plungers, which have a much longer stroke than that of the re-pressing plungers. The briquettes thus ejected drop from the molds upon a conveyor belt.

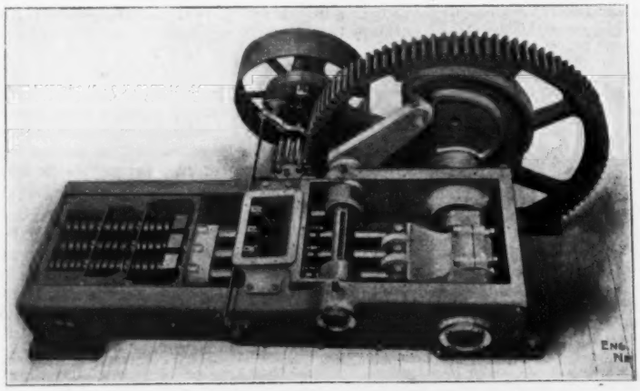


FIG. 6. PERSPECTIVE VIEW OF PLUNGER BRIQUETTING MACHINE.

This type of machine is now built by the Chisholm, Boyd & White Co., of Chicago, which has built about 50 machines, while the number now ordered and being built bring the total up to about 60. Seven of these have been built or ordered during the present year. Of the machines already installed, all but two are said to be in regular operation; the two now out of service are the first one built (which has been replaced by one of later construction), and one built for the Carrie Furnace plant, at Rankin, Pa., where the use of the briquetting process has been abandoned, as already noted.

Fig. 1 is a general plan of the machine, showing a mold-plate with two rows of molds. Fig. 2 is a view of a similar machine, having four rows of molds. This latter machine re-presses eight briquettes and ejects eight others at each stroke of the toggle shaft, corresponding to each movement of the mold-plate. At the left are the crank and rod operating the arm on the toggle shaft, while beyond the re-pressing device is the ejector arm with eight plungers. On the right is the sprocket wheel of the belt conveyor shaft.

The preliminary mixing of the flue dust or ore with the bonding medium is accomplished by auxiliary machinery, independent of the press. It is claimed, however, that the pugging in the Chilean mill is an important feature in effecting a thorough mixing of the materials. While a cream of lime is most commonly used, as has already been explained, the Chisholm, Boyd & White Co. has a patented bond material intended specially for use with iron ore, and this is used to some extent, as mentioned in the foregoing description of the Illinois Steel Co.'s plant.

Fig. 3 is a view of the auxiliary machinery used by this company. The upper steel trough is the lime mixer; it is divided into two compartments by a vertical perforated diaphragm or strainer, and has a shaft extending through it. The freshly burned lime and the water are charged into the first compartment, and are churned and agitated by blades on the shaft so as to form a cream of lime, which is drawn out by a 6-in. pump from an opening at the end of the second compartment. The pump delivers this liquid to the mixing trough. The short vertical cylinder at the end of the lime mixer is the device for automatically feeding the flue dust or other material. In it is a cast-iron hopper, open at the bottom, and having an adjustable extension or sleeve. At the bottom is a horizontal disk on a vertical shaft driven by the bevel gearing shown beneath the hopper. The dust falling upon this disk is thrown by centrifugal force into the mixer, the quantity being regulated by the distance between the disk and the adjustable sleeve. The steel trough to the right of the feeder is the mixer, and is 10 ft. in length. Through the entire length of the trough extends a shaft having blades which stir and mix the dust and the cream of lime to the consistency of a stiff paste, the blades also forcing the mixture along the trough and into a chute, from which it falls upon a belt which delivers it to the pan of the pressing machine. Fig. 4 is a general elevation showing the arrangement of a briquetting plant.

As already noted, a modified design of the disk machine was at one time made. In this the Chilean or pan mill was retained, together with the

mold disk; but the latter only extended across about two-thirds of the width of the roller-track plate, and was dropped about ½-in. below the level of that plate. In this way the rollers could not come in contact with the mold-plate, and the pressure on the molds was lessened. The rollers were also made of lighter weight, so as simply to fill the molds, since re-pressing of the briquettes was necessary in any case. Outside of and above the pan was a horizontal lever or rocking beam, one end of which was given a reciprocating motion by a vertical connecting rod from a crank, corresponding to the rod and crank which operate the toggle in the machine already described. Pivoted to the beam, and hanging below it were two arms, each carrying two plungers (for a mold-plate with two rows of holes). The plungers nearest the pivoted end of the beam, which have the shortest stroke and exert the greatest pressure, form the re-pressing device. The others form the ejectors.

The apparatus for rotating the mold-plate was entirely different from that already described, and was independent of the plate itself, so as not to cause any wear or distortion of the holes by the continual action of the pawl or plug. The mold-plate was bolted to the upper flange of a short heavy shaft running in long sleeve bearings, while to the lower flange was bolted a large horizontal ratchet wheel. The shaft extended below this wheel and carried a rocking arm to which a pawl was attached. This arm was driven by a horizontal rod from the same crank which drove the re-pressing device. Only two machines of this type have been built (by the Henry S. Mould Co.), and both of these were sent to the Broken Hill Proprietary Co., at Port Pirie, New South Wales, Australia.

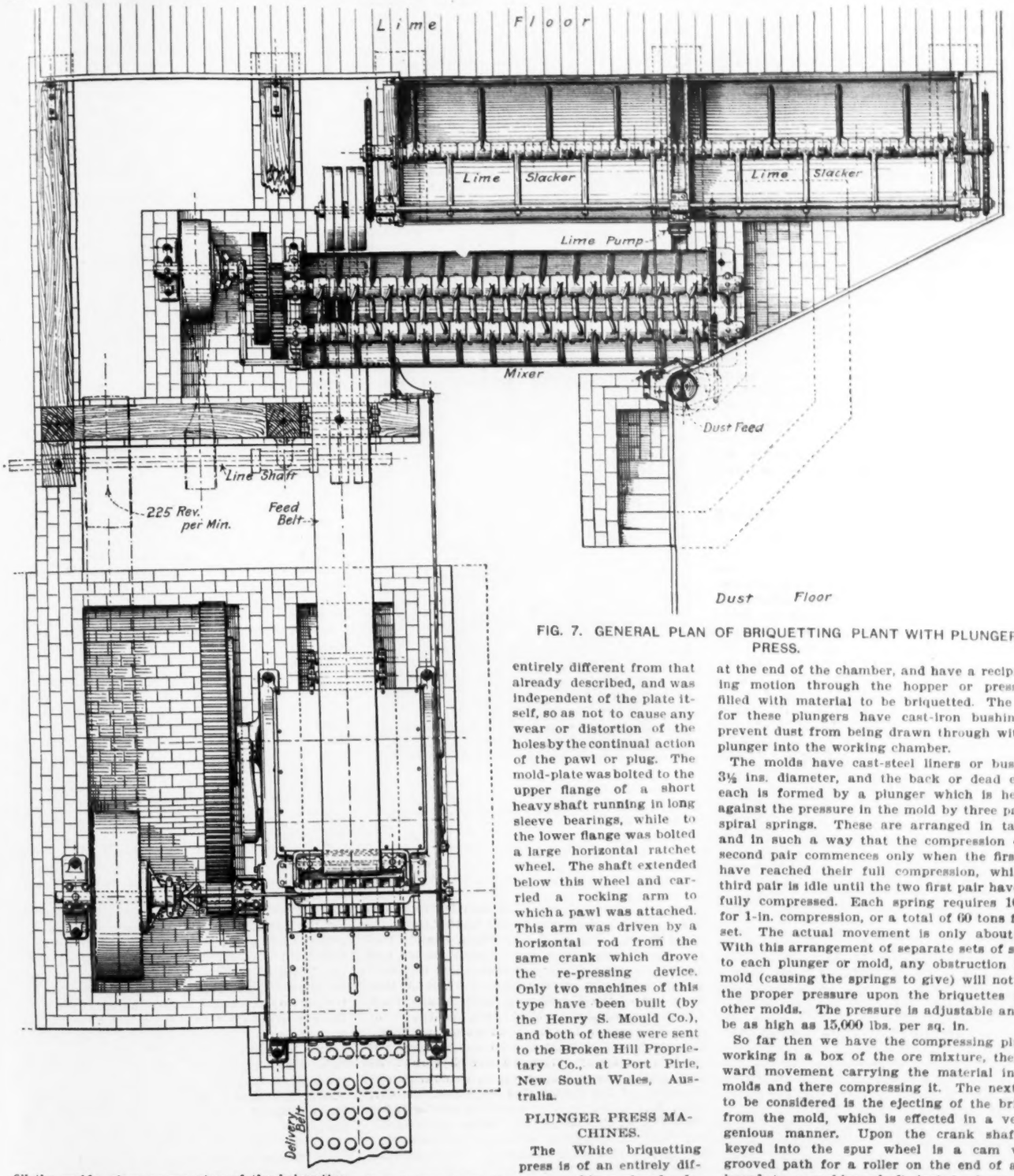


FIG. 7. GENERAL PLAN OF BRIQUETTING PLANT WITH PLUNGER PRESS.

PLUNGER PRESS MACHINES.

The White briquetting press is of an entirely different type from the two machines already described, and dispenses with the rollers, the mold disk and the re-pressing arrangement. It is a horizontal reciprocating press, with a series of horizontal plungers worked from a crank shaft and compressing the material into molds backed by other plungers reinforced by heavy springs. Fig. 5 is a view of the interior, but in practice this is all enclosed by steel cover plates bolted onto the heavy frame castings.

The 5-ft. belt pulley has on its shaft a pinion gearing with an 8-ft. spur wheel keyed to the end of the crank shaft. A pitman driven by the crank is attached to a sliding crosshead which carries the plungers. These slide in stuffing boxes at the end of the chamber, and have a reciprocating motion through the hopper or press box filled with material to be briquetted. The holes for these plungers have cast-iron bushings to prevent dust from being drawn through with the plunger into the working chamber.

The molds have cast-steel liners or bushings, 3⅛ ins. diameter, and the back or dead end of each is formed by a plunger which is held up against the pressure in the mold by three pairs of spiral springs. These are arranged in tandem, and in such a way that the compression of the second pair commences only when the first pair have reached their full compression, while the third pair is idle until the two first pair have been fully compressed. Each spring requires 10 tons for 1-in. compression, or a total of 60 tons for the set. The actual movement is only about ¼-in. With this arrangement of separate sets of springs to each plunger or mold, any obstruction in one mold (causing the springs to give) will not affect the proper pressure upon the briquettes in the other molds. The pressure is adjustable and may be as high as 15,000 lbs. per sq. in.

So far then we have the compressing plungers working in a box of the ore mixture, their forward movement carrying the material into the molds and there compressing it. The next thing to be considered is the ejecting of the briquette from the mold, which is effected in a very ingenious manner. Upon the crank shaft, and keyed into the spur wheel is a cam with a grooved path for a roller on the end of an arm keyed to a rocking shaft just in front of the hopper. Two vertical crank arms on the under side of this shaft, just within the frame, are attached by links to the press box, which (with the block carrying the molds) has a horizontal reciprocating motion. The cam is so laid out that as the main crank shaft withdraws the plungers, the second shaft pulls back the molds in the same

direction, but at greater speed. The molds are thus slipped over the plungers, which thus also serve as ejectors, the briquettes dropping upon a conveyor belt beneath the machine. The cam then returns the box and molds to position before the plungers commence a new stroke. Graduated scales on the mold box show the amount of compression of the backing springs. All the mechanism is contained within a heavy box frame casting and is entirely enclosed. The frame is divided into two compartments. The first of these contains the crank-shaft, pitman, and mold shaft, and forms an oil chamber. These machines are built by the Henry S. Mould Co., of Pittsburg, Pa., and about 46 have been installed at different points.

A plan of a complete briquetting plant is shown in Fig. 6. At the top of the plan are the two lime slackers for preparing the solution. These are driven independently by belts, and either one may be started and stopped at will. The cream of lime is pumped alternately from these by a pump driven by a chain from one of the shafts of the mixer, the amount of lime being regulated by adjusting the throw of the pump by means of a hand wheel. The dust is fed from above by the automatic dust-feeding device shown at the end of the mixer. This device is driven by a chain from one of the mixer shafts, and the amount of feed is regulated by means of a hand wheel. The dust and the cream of lime are delivered into the upper end of the mixing trough, which has two shafts fitted with blades which mix the materials together and carry the mixture gradually to the delivering end of the trough, where it falls upon a belt conveyor running to the hopper of the briquetting press. Another belt conveyor removes the briquettes as they drop from the press.

THE INAUGURATION OF PRESIDENT ALEXANDER C. HUMPHREYS AT STEVENS INSTITUTE.

A notable event in engineering educational circles during the past week was the formal inauguration of the new President of Stevens Institute, Mr. Alexander Crombie Humphreys, which took place on the afternoon of Feb. 4 in the new Carnegie Engineering Laboratory on the Institute grounds.

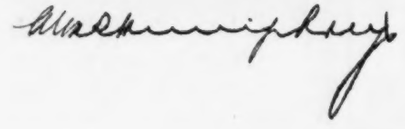
As many of our readers will remember, Stevens Institute was founded by the late Edwin A. Stevens and was the first American school devoted exclusively to mechanical engineering. Dr. Henry Morton was its first President and he served for 31 years until his death in May last. Starting in a modest way but maintaining from the outset a high standard, the school graduated only 86 students in the first ten years of its existence. In the past ten years it has graduated 511. While at the outset the idea of a school training for mechanical engineers was so novel that the first few graduates found difficulty in securing places on any terms, at the present time the reputation made by Stevens men is such that the demand for graduates is in excess of the supply and men are frequently engaged a year in advance of their graduation.

The wide reputation of President Morton as a scientist and an educator has made his place a difficult one to fill; but the selection of Mr. Humphreys is universally accepted as a fortunate choice. His professional record has been unique. He entered Stevens Institute in 1881 when 30 years of age, and for four years pursued his studies at the Institute while at the same time holding the position of Superintendent of the gas company supplying Bayonne, N. J. He spent two mornings a week attending lectures at the Institute and in 1885 graduated with honors, a special vote of the faculty at the time certifying to his excellent attainments in his studies under such unusual circumstances. On graduation he became Chief Engineer of the Safety Car Heating and Lighting Co., but soon resigned to take charge of the work of the United Gas Improvement Co. of Philadelphia. This company purchased gas plants in cities of moderate size in different parts of the country and remodeled them to use new water gas processes. During the ten years Mr. Humphreys remained with this company he effected remarkable results in organizing, systematizing and developing its business and to this work its great prosperity has been largely due.

In 1894 Mr. Humphreys withdrew from this company and formed with a Stevens classmate the firm of Humphreys & Glasgow, which has carried on the business of constructing water gas apparatus in foreign countries and of consulting gas engineers in the United States. Since its organization the London office has constructed water gas apparatus with a daily capacity of 130,375,000 cu. ft. In connection with this work Mr. Humphreys has served as the chief executive officer of over 50 gas companies and he is now President of the Buffalo Gas Co. and of the Hibbard-Rodman-Ely Safe Co. He is a member of many engineering and scientific societies and has been a trustee of Stevens Institute since 1891.

The formal inauguration of Mr. Humphreys was attended by numerous representatives of other colleges and engineering schools, and addresses were made by President Chas. F. Thwing, of Western Reserve University; Dr. H. S. Pritchett, President of the Massachusetts Institute of Technology; Mr. Andrew Carnegie; Prof. Robb, of Rensselaer Polytechnic Institute; Prof. Marburg, of the University of Pennsylvania; and others.

On the evening after the inauguration a dinner was given by the Alumni to President Humphreys at Sherry's which was attended by about 500 students and alumni of the Institute and invited guests. Mr. W. S. Ackerman, President of the Alumni Association, was the toastmaster, and among the after dinner speakers were: Governor Franklin Murphy, of New Jersey; Col. E. A. Stevens, son of the Founder of the Institute; Prof. Chittenden, of the Sheffield Scientific School of Yale University; Dr. R H. Thurston, of Sibley College, Cornell University, who was a member of the Stevens faculty during the first 14 years of the Institute's history; Walton Clark, General Superintendent of the United Gas Improvement Co.; Capt. W. H. White, Vice-President of the Lotos Club; Col. H. G. Prout, of the "Railroad Gazette;" Dr. Chas. F. Chandler, of Columbia University; and Mr. E. E. Olcott, President of the American Institute of Mining Engineers.



An important announcement made at the dinner is that Col. Edwin A. Stevens and his brother, Mr. Robert L. Stevens, have given to the Institute a plot of land in the block adjoining the Institute grounds to be used for the erection of a dormitory, funds for constructing which, it is hoped, may shortly be raised.

THE RELATIONS BETWEEN ENGINEERS AND CONTRACTORS.

By A. C. E.

The several letters which have recently appeared in Engineering News concerning specifications, and the relations of engineers to contractors, have been very interesting. In reflecting upon the questions that have been under consideration, it has occurred to me that there are some other points, relating to railway engineering and contracting, that have not been brought out, particularly the kind of preparation which the young engineer has to fit him to direct the operations of a contractor; the instructions he receives from his superiors as to the position he occupies in directing one of the parties to a contract, and, also, the way in which the chief engineer exercises his authority in rendering decisions on questions growing out of a contract.

It seems as if responsible and experienced contractors should know very closely what it costs to do work; but the wide range of prices in competitive bidding indicates that there may be conditions in the contracts or specifications which are elements of risk. Prices for work would be generally lower, if the uncertainties were removed, or if contractors did not have to try to make up this year for last year's losses due to misunderstandings or to circumstances not contemplated by either party.

The personal experience of every engineer will afford incidents for illustration from the lowest "rung" up to whatever point he may have reached on the ladder of fame.

The university which honored me with the degree of civil engineer gave me no instructions as to my duties in relation to contractors. Contracts and specifications were less familiar to me than the theorem of Pappus. The first contractor who accosted me on my first piece of work asked, "What is the width of berme?" Having never heard the word "berme," it was necessary for me to clear my throat before answering.

Later, a contractor demurred because I insisted that the material excavated from surface ditches should be hauled into fills. My superior afterwards advised me that there was nothing in the contract *prohibiting* such hauling, but that it was customary to deposit ditch material between the top of slope and the ditch.

Again, while taking a constitutional in a ten-mile stroll, so necessary to the engineer's existence and forming such a large part of his professional duties, especially as regards the amount of time consumed, I was invited to sit upon the justice's bench and listen to the appeal of an Irishman who had been digging a ditch in a muck swamp at ten cents a yard. Pointing to the network of roots and logs in the unfinished ditch, he said, "Be jabbers, an Oi ort ter git loose rock fer ivery yard uv thot."

My instructions had been meager. In a vague way, I knew that the contractor had agreed to do something and that I was to measure it up once a month. My experience soon taught me that there were conditions and specifications governing the prosecution of work, some of which were contained in a written contract, and others in an unwritten law of common practice. These written forms of contract show that there are very many conditions binding the party called the contractor to do, or not to do, certain things; but there is seldom a clause indicating that the contractor has any rights which the other party is bound to respect. It is always found that the Chief Engineer is made the umpire between the parties and that his decision shall be final.

Now, how does it work out in actual practice? The details of the work are left to young men, lately from the engineering schools, and very few of the questions that arise ever come before the Chief Engineer, who sometimes makes his first trip over the work after the rails are laid. The contractor sometimes makes mild protest to the assistant engineer, when required to do things which are violations of the spirit and letter of the contract, and the man named to decide questions never knows that the lack of instructions to his subordinate has led to an injustice. Under these conditions it is surprising how little friction there

is between the engineers and contractors. I suspect that the contractors have figured a margin for safety. It is noticeable that the same contractors will be awarded work on the same railway, year after year, under competitive bids. Is it due to the fact that they know what the rulings will be, on matters that cause others to add something for safety?

There seems to be a difference of opinion as to the meaning of the words used in the various expressions which say that the Chief Engineer or his subordinates shall direct and decide between the parties. Does it mean watchfulness to see that the contractor's interests are protected, and to see that compensation is made for all deviations from the contract?

Does the exhibit of profile indicating the character of work bind the "Company" in any way? It is sometimes difficult to say what is a deviation, owing to the binders that are used to guard every possible imaginable contingency. Is it not a mistake to exhibit a map and profile of a line, enter into an agreement to build it, and have it written in a contract, that if the railway company or its Chief Engineer wishes to move the line into the next county and change the character of the work, it may be done regardless of the effect upon the contractor? Such clauses cost the railway companies a good deal of money. It is an open decision whether or not they should be held up for larger sums, in supplemental agreements, claims, and damage suits, if the effect of changes were not to be determined after the recurrence.

Specifications sometimes contain paragraphs that are very exasperating and humiliating to one or both parties and certainly to the engineer in charge. A printed form of contract contains a condition that the books of the contractor shall at all times be open for inspection, by the Chief Engineer or his subordinates; that complete pay rolls for labor and copies of all bills for material shall be filed before the 15th of each month with the Chief Engineer; and, if he so elects, all accounts shall be paid by him and the amount deducted from the estimates.

Could the railway company place an order for equipment subject to such conditions? What man would like to undertake a piece of work with a copy of such an agreement in the hands of every official of the company with whom he had dealings? Does a chief engineer willingly enter into an agreement with a party that he thinks needs such supervision?

Before any agreement is written, the parties should qualify and the qualification should cause the elimination of many unnecessary paragraphs. Sometimes engineers request bids for work in two or more ways, as regards haul, or classification. There is in this just a suspicion that there may be some uncertain element which will operate in the railway company's favor. Is the Chief Engineer any more an impartial umpire after a contract is signed than before?

It ought to be apparent to every engineer that the more nearly he can define each class of work, the more accurately the cost can be determined by the contractor. The price will then contain the smallest margin of profit.

These ideas hinting somewhat at reform will meet with criticism, and of myself the contractors will say, "A Daniel come to judgment." My brother engineers will say, "First cast out the beam out of thine own eye, and then shalt thou see clearly to cast out the mote, etc.," and there may be others so uncharitable as to say, "When the wind is southerly he knows a hawk from a handsaw."

The matter needs a little more agitation to show just where to begin, to bring about the changes necessary to place the relations between engineers and contractors on a basis similar to other business enterprises.

I suggest that the technical schools give more attention to specifications and the related questions; that the chief engineers advise their subordinates in these matters while writing hundreds of letters relating to other parts of their duties; that every contract be made to define as closely as possible the work to be done under the direction of the Chief Engineer, who should be privileged to alter, add to, or discard, as the railway company may desire; and that a consulting engineer be named, to be called in, if necessary, to determine the value of any changes. His fee should be paid jointly by the parties.

THE NEW YORK RAPID TRANSIT RAILWAY.

XVI.

Contract Section XI.

Contract Section XI. of the Rapid Transit Railway extends from the center line of 104th St., along Broadway to a point 10 ft. north of the south side of 125th St. The subcontractor for the work is John Shields, New York, N. Y.

SUBWAY STRUCTURE.—Section XI. is the initial section of the West Side line, and was originally designed for two tracks. In fact, work was commenced for a two-track structure, and was completed in places before it was determined to alter the original plans. The considerations which led to the change of plans were briefly stated as follows: Under the terms of his contract the general contractor was privileged to select the location for the necessary underground terminal space required by him in the operation of the road. In exercising his privilege the contractor chose to locate this terminal space adjacent to the main tracks, between 135th and 145th streets, and from these yards to carry a third track south to the beginning of the four-track line at 104th St. He, therefore, asked the Rapid Transit Commissioners to order the third track as extra work and offered to undo at his own expense such double-track work as had been completed. This request was granted by the Commissioners.

According to the original plans, the subway structure was to be double-track standard subway from 104th St. to the north end of the station at 116th St., and from that point to 121st St., on account of the depth of the cut, it was to be double-track concrete tunnel. From 121st St. to 122d St. it was to be standard subway, and from 122d St. to 125th St. it was to be partly in cut and partly on embankment between retaining walls. At the time the change was ordered about 215 ft. of the tunnel structure had been completed, but the other work was not so far advanced as to necessitate the demolition of any large amount of the work already done. The change added another roof beam and column to the original standard two-track structure, substituted a three-track tunnel for the original two-track tunnel, between 116th St. station and 120th St., and widened the cut and embankment from 122d St. north.

The new three-track tunnel section is the only one of the revised plans which calls for description. Fig. 103 shows a construction of this tunnel. It has a polycentric roof arch and vertical sidewalls 38½ ft. apart. The roof clearance above base of rail at the center is 19 ft. 10 ins. The only feature of the lining calling for particular notice is the thinness of the sidewalls, and this was made possible by nature of the material penetrated, which was a tough mica-schist rock standing perfectly under excavation.

The grades on Section XI., excepting the approaches to the Harlem River Tunnel, include some of the steepest grades on the whole line. In detail, they are ascending from 104th St. north as follows: 1.08%, 0.7%, 1.5% and 1.98%; and descending from 116th St. north as follows: 1.91% and 0.37%. These grades are broken by stretches of level track opposite the platforms of the stations at 110th and 116th streets.

MATERIALS PENETRATED.—The subsoil underlying Broadway, from 104th St. to 125th St., is a mica-schist rock covered with a thin layer of earth. At a few points the earth covering dips to some depth, but in most places it is only 2 or 3 ft. deep. Generally speaking, therefore, rock

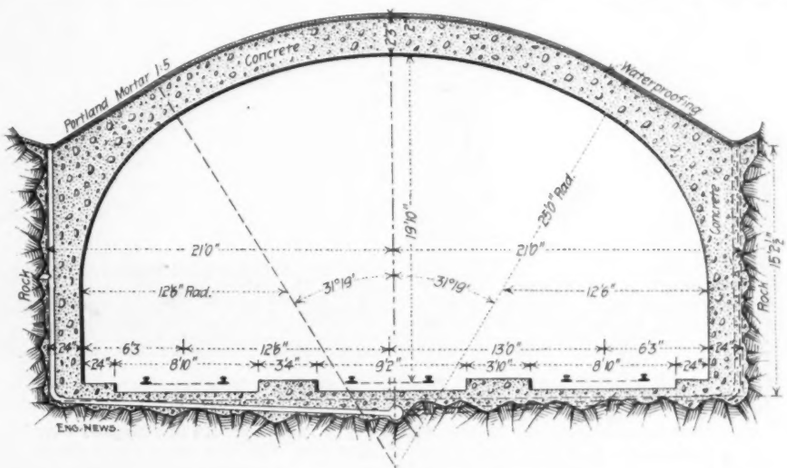


FIG. 103. TRANSVERSE SECTION OF THREE-TRACK CONCRETE TUNNEL ON SECTION XI.

excavating methods and machinery were exclusively employed.

STREET AND ADJACENT STRUCTURES.—A double-track conduit electric railway occupies Broadway for nearly the whole length of the section, and this was practically the only structure along the work which necessitated any special care during construction. Broadway is here occupied in part by a central parkway, and the car tracks run close to the edges of this parkway one on each side. Throughout the underground portions of the road both of the car tracks had to be supported during construction and restored to their original alinement and grade, but where the road comes above ground in cut and embankment these tracks had to be rebuilt far enough apart to clear the new structure. The method of making this change was rather interesting and will be described here.

In the diagram, Fig. 104, the dash lines show the original axes of the two tracks, and the full lines

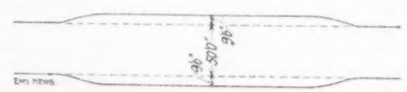


Fig. 104. Diagram Showing Change in Surface Railway Tracks to Clear Open Cut and Embankment at North End of Section XI.

show their axes as rebuilt. As will be seen, each track was thrown 9½ ft. toward the side of the street. Each track, as before stated, is for a conduit electric railway. The yokes are spaced 5 ft. apart, and rest on a 6-in. concrete foundation, and between the yokes is the familiar concrete conduit construction. The plan of reconstruction decided upon was to shift each track structure bodily to its new position. To do this a trench was first excavated the full width of the proposed sidewise movement, and deep enough to clear the bottom of the old concrete foundation under the yokes. A channel was then cut through the concrete foundation under every other yoke. Into these channels 8 × 8-in. timbers were thrust endwise, so as to extend clear across the trench. On these timbers old rails were spiked to furnish

FIG. 105. VIEW OF EXCAVATION FOR THREE-TRACK STANDARD SUBWAY STRUCTURE, SHOWING TIMBERING OF SURFACE RAILWAY TRACKS.

tracks on which the yokes could be slid, and then the earth was cleared away from around and beneath the track structure, leaving it supported on these tracks. A new concrete foundation was then built in the proper position in the trench for the new location of the track. This foundation was put in between the track timbers. When this foundation had hardened the track structure was jacked sidewise, sliding on the cross timbers, until it was over the new foundation. The old and new foundation were then grouted together. The cross beams were then removed and the spaces occupied by them were filled with concrete. The restoration of the street completed the work, which was done without interrupting the street car traffic.

METHODS OF WORK.—The method of work followed was to open a single wide trench, supporting the street railway tracks on timbering, and build the subway structure within this trench. Several methods of supporting the street railway structure were employed. One of these was the parallel truss and needle beam method employed on Sections VI-a and VI-b, as already described. The more common method, however, was to excavate under the track structure, insert a needle beam under the track about every 10 ft., and strut down from this beam as the excavation deepened until subgrade was reached, when long posts were inserted, as shown by Fig. 105. This view shows the arrangement of the trench timbering and track supports so clearly as to make further description unnecessary. A third method of track support was employed where the deep cut for the concrete tunnel section occurred. It was the original plan to tunnel this stretch of the work, but the substitution of the wider tunnel and the unsatisfactory material encountered led the contractors to substitute an open cut in place of tunneling. This cut at the deepest point was about 40 ft. To carry the car tracks over this it was spanned from side to side with double I-beam girders, on the tops of which the track structure was blocked up, as shown by Fig. 106. The great advantage of this method of track support was that it gave a clear space for the construction of the concrete arch.

The building of the subway structure within the excavation involved no unusual methods. When standard three-track construction was employed the method was to lay the concrete floor, and set the column pedestals, as shown by Fig. 105. The steelwork was then erected and riveted and the sidewall jack arches and the roof arches then built on centers in the usual manner. To build the tunnel section a sidewall mold of simple construction, as shown by Fig. 106, was erected, and the concrete filled in behind it. The roof arch was then built on centers of the form shown by Fig. 106. After completing the roof arch, it was filled above with stone, and stone piers were built at intervals on both the arch and the standard subway to carry permanently the street car tracks above.

The removal of the earth and rock from the excavation was accomplished nearly altogether by cableways. Six of these devices were used, one of which was a species of telpherage cableway, and is deserving of individual mention because of its novelty, although as used it was hardly as satisfactory a conveying device as some of the others. The telpherage cableway was designed by Mr. W. F. Brothers, of New York city. The chief novelties of the device were the method of supporting the main cable and the use of a carriage operated by an electric motor on the carriage itself.

Figs. 107 and 108 show the method of supporting the main cable. As will be seen, the cable is fastened at each end to the peak of an inclined A-frame, which is loaded with a weight and is free to swing up and down on its feet as a hinge or pivot. The cables supporting the weights are of such lengths that both weights cannot rest upon the ground at the same time. The proper magnitude of these weights is known from the deflection of the main cable when it is hanging freely. When the carriage travels away from one of the A-frames the main cable sags, and the weight at that end rises, as shown by Fig. 108, but when the carriage returns the change in the inclination of the main cable at the point where it is attached to the A-frame is sufficient to give the weight a preponderance, and it comes to rest, as shown by Fig. 107. The principle of this action may be understood from the triangle of forces shown in Fig. 109. Here A B represents the constant vertical force exerted by the weight; B C represents the pull on the main cable, and C A represents the thrust in the A-frame. If now the inclination of the main cable be changed to b C, then A B will be greater than the resultant of b C and C A, and will pull the end of the A-frame down until a new position of equilibrium is reached, as indicated by the triangle A B C'. The work done by the falling weight is expended in lifting the load on the carriage, so that the motor is assisted a certain amount as it approaches the A-frame. In practice the principle worked only at one end of the cableway, the weight at the other end always resting on the ground.

Fig. 107 shows in a general way the carriage. The operator rides on this carriage, and from his seat controls all its operations by means of a system of switches. For the cableway being described a 15-HP. motor was used, which enabled a 3-ton load to be hoisted and propelled along the main cable. A trolley wire suspended under the main cable furnished current to the motor. As will be

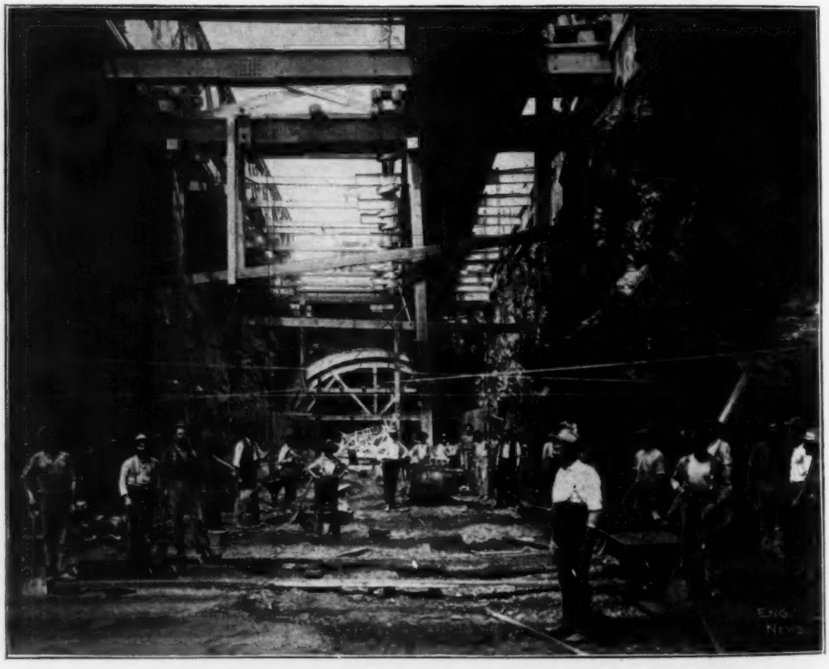


FIG. 106. VIEW SHOWING STEEL GIRDERS TO CARRY SURFACE RAILWAY TRACKS OVER DEEP CUT TUNNEL SECTION.

understood, the carriage was capable of motion in both directions along the main cable and was also capable of both a lowering and a hoisting motion. For the work being described the operation of the carriage furnished proved too slow, but in other respects the operation of the device was quite satisfactory. With a carriage designed for higher speed much better results would probably have been secured. One feature of the device which proved especially satisfactory was its ability to take the load beyond the feet of the A-frame and clear of the end of the trench, as shown by Fig. 107.

FIGS. 107 AND 108. VIEWS SHOWING A-FRAME SUPPORTS FOR TELPHERAGE CABLEWAY ON SECTION XI.

POWER PLANT.—The electric current for operating the telpherage cableway was taken from the local electric light mains, but all other machinery was operated by compressed air from a power plant built by the contractor at Broadway and 118th St. This plant consisted of a Rand 24 × 30-in. straight line compressor receiving steam from a 150-HP. boiler and delivering air to a 4 × 15-ft. receiver. The supply pipe ran north and south from the power plant to the opposite each end of the section.

ENGINEERS.—The work of Section XI. was carried out under the supervision of Mr. Beverly R. Value, Division Engineer for the Rapid Transit Commission; Mr. C. V. V. Powers, Senior Assistant Engineer, and Mr. Wilson Fitch Smith, Assistant Engineer in direct charge of construction, and Mr. J. T. Shipman, Engineer for the subcontractor.

HOW TO PAN GOLD FROM GRAVEL.*

The gold pan, or prospector's pan, is used chiefly for two purposes: (1) to test gold bearing gravels, or finely crushed ore containing particles of free gold; (2) for making small scale concentration tests on any ore in which the useful mineral has a higher specific gravity than the associated gangue.

To make a careful test sufficient gravel or crushed ore is weighed out to about three-fourths fill the pan (say 5 kilograms or 11 lbs.). In somewhat rougher work the pan may be filled level full—"struck measure." If a larger charge than this be taken the result is apt to be less accurate.

The operations are as follows:

1. Carefully sink the pan of material horizontally just under the surface of the water, and with the hands thoroughly mix the contents until all parts are wetted. If there be any partly cemented gravel, earthy or cohesive material, it must be completely disintegrated by rubbing between the hands to liberate associated particles of gold or other useful mineral. While doing this, guard against any movement which may throw material over the sides of the pan. In treating gold gravel the larger stones and pebbles are washed clean and thrown out. They should be examined afterward, and if likely to contain gold may be crushed and washed separately. For ores, which must be previously crushed fine enough to liberate the particles of useful mineral, the kneading and mixing process may be somewhat shortened. This preliminary treatment tends to cause the gold or other heavy mineral to settle in some degree towards the bottom of the pan, while at the same time part of the fine, barren material is floated off.

2. Still holding the pan horizontally, raise it until the edge is just above the surface of the water. Then, keeping the pan nearly full of water, gently and with a short gyratory and shaking motion, level down the contents. Continue this motion, without losing any of the material over the sides, until the entire contents are thoroughly loosened up, with no part "packed" and immovable on bottom or sides of the pan. This causes a still further settlement of the heavy mineral.

3. Tilt the pan forward at a few degrees to the horizontal, and balance it in the hands with the forward two-thirds slightly under water. Holding the pan in this position, give it a horizontal oval movement, outward from right to left and bringing it back to complete the curve. In thrusting the pan forward the water flows up over the contents in a thin sheet; in drawing it back, this water flows off over the left-hand side of the pan carrying with it part of the fine stuff forming the upper layer. The forward motion should be rather slow and deliberate, the backward movement quicker to assist the outflowing water in carrying off the material. Repeat this operation in rapid succession three of four times, not more.

4. Bring the pan to a level, under water, and, to continue the settling process, resume the gyratory shaking motion for a few moments. Vary this from time to time by giving the pan short, quick forward and backward and sidewise movements, to loosen the contents, which during the washing off becomes packed and solid. While doing this, still be careful to throw no material over the sides.

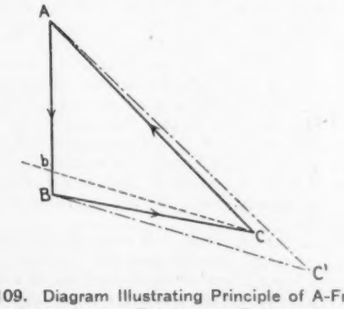


Fig. 109. Diagram Illustrating Principle of A-Frame Supports for Telpherage Cableway.

5. Return now to the movements detailed in Sections 3 and 4, alternating the operations until so much of the fine material has been washed away that the larger gravel or pieces or ore begin to appear at the surface. These are raked out with the fingers, and thrown to waste, or kept for further examination (see latter part of Section 1).

6. Resume the agitation, alternately washing off and settling, until the pan contents consist mainly of useful mineral or black iron sand. If the material tested be an ore, the concentrated mineral is now removed from the pan, dried and weighed.

7. Treatment of black sand, containing free gold. This is further reduced in volume by tilting the pan forward at a steep angle, with the rim just under water, and giving it slow forward and quick backward movements. Alternate at frequent intervals with the shaking motion to settle the gold. If desired, the washing may be continued carefully until nearly all the black sand has been removed, or until the particles ("colors") of gold begin to appear. From time to time, by a circular tilting motion, with a little water, the sands may be swept around the angle of the pan in a tail-like form, uncovering the gold as the lighter sand is carried forward. By careful work nearly all the sand may be washed off, leaving little besides the particles of gold. Then, tilt the pan nearly vertically the edge resting upon a piece of writing paper, and with the aid of a few drops of water push the gold with the finger upon the paper. After drying, the remaining grains of sand are blown away. Before weighing it is well to count the "colors" of gold, when the number is moderate, to become accustomed to estimating their values.

If the gold be in very fine particles, it is not safe to wash down completely. Instead, the black sand with the gold is dried and assayed by fire.

By means of the pan, ore or gold gravel of extremely low value may be quickly and successfully tested, results sufficiently accurate being obtainable from material far too poor to be treated by fire assay. With ordinary care particles of gold of a very small fraction of a cent in value can be saved with certainty. In panning low grade sulphuret ore or cassiterite, or any friable mineral, it is often necessary to save the washings from the first panning, re-pan them, and add the result to that first obtained. This may be repeated several times when required. Gold ores, also, in which the gold is very finely divided, may be re-treated.

In panning gold gravel, not so much for testing purposes as to wash quickly large quantities of material, for the value contained, the pan is usually heaped, and the washing less carefully conducted. For such purposes, as well as for testing very low grade gold-bearing gravel, time is saved by not washing down completely each panful, but, after reducing the charge to say an ounce or two, transferring the black sand to another pan. The enriched residues from a number of pans may then be completely washed in one operation and the gold separated. It may be added that in field work, since quantities of gravel are usually estimated in cubic yards, it is preferable to deal with volumes rather than with weights. A little practice enables the panner to take each time a uniform quantity of gravel, which is a certain fraction of a cubic yard, making his calculations on the basis of say 200 pans per yard.

*Taken from printed instructions, by Prof. Henry S. Munroe, for students in the ore dressing laboratory of the School of Mines, Columbia University, New York.

A PENDULUM PROPELLER was recently tested at Copenhagen, Denmark, on a launch for a Russian cruiser. The principle of the propeller is simply that of an oscillating rudder, the water being propelled backward as air is driven by a lady's fan. The advantages claimed are greater efficiency in propulsion than with the screw on account of the much larger body of water moved and the reduced skin friction. The launch equipped was about 30 ft. long and attained a speed of nearly 8 knots. The propeller is the invention of Mr. H. C. Vogt, M. Inst. Danish C. E., of Copenhagen.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, - - - - MANAGING EDITOR.
F. P. BURT, - - - - - - - - - BUSINESS MANAGER.

M. N. BAKER, CHAS. S. HILL, - - - - } ASSOCIATE
E. E. R. TRATMAN, F. E. SCHMITT, - - - - } EDITORS.
WM. KENT, H. P. GILLETTE, - - - - -

CHAS. W. REINHARDT, - - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston,
} ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE., 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; *6 months,* $2.50; *10 weeks,* $1.00. *To all other countries in the Postal Union: Regular Edition, One Year,* $8.00; *Thin Paper Edition, One Year,* $6.75. *SINGLE COPIES of any number in current Volume,* 15 *cents.*

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 *means that subscription is paid to the* 32d *week (that is the issue of Aug.* 6) *of the year* 1903; *the change of these figures is the only receipt, unless one is sent by special request.*

ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

American cities have made rapid progress in recent years toward the municipal ownership of their systems of water supply, until by far the larger proportion of the residents of cities in this country take water from public works. In the field of electric lighting, also, municipal ownership is making rapid advancement. When we come to the gas supply, however, we find no movement whatever in the direction of municipal ownership.

It is of interest to inquire the reason for this. A common reason given—and a superficial one—is that the gas business is too technical and complicated for a city to undertake. Probably the best answer to this is the success of municipally-owned gas plants in Europe, and particularly in England. There appears to be no more trouble there in conducting a municipal gas plant than a municipal system of water supply.

It is also commonly said that private companies can handle such matters as the manufacture and supply of gas very much more efficiently than city governments. As a matter of actual history, however, American gas engineering, up to the time of the introduction of the modern water-gas processes, was a long way behind European engineering in this field. The gas companies charged such huge prices for their product that they could afford to, and in many cases did, wholly neglect the management of their works; and many plants were carried on wastefully and extravagantly, simply because there was no necessity for economical and careful management.

During the past 15 or 20 years there has been much improvement; for owners of private gas works have come to realize that there is more money to be made in selling a large quantity of gas at a moderate price than a small quantity at an exorbitant price. Nevertheless, the public is still being taxed to pay dividends upon many millions of watered gas stocks; and there are many strong arguments to be presented in favor of municipal ownership of gas works.

It is not our purpose to rehearse these arguments now, but instead to point out the peculiar difficulties which lie in the way of any city which may desire to build gas works for itself or to purchase existing works from a company. This difficulty lies in the lack of competent and experienced gas engineers who are willing to enter the service of a municipality. Practically all American gas engineers have gained their professional experience in the service of gas companies; and so strong is the prejudice against municipal ownership among gas men that we believe a city attempting to enter this field would find considerable difficulty in securing competent professional advice. Further, there is reason to suppose that the engineer who might choose to enter a city's service—let us say as an expert in connection with the purchase of a company's plant—would run the risk of cutting himself off from any future employment by gas companies. In short, there is evidence that the gas interests of the United States are determined to keep the gas industry in private hands and to use any measures necessary to keep municipal ownership out of this field.

We wish to speak in outspoken condemnation of this policy. There is no more reason why the business of gas supply should be monopolized in private hands than the business of water supply. If any American city desires to adopt municipal ownership for its gas supply, it is against public policy that it should be hindered in so doing; yet it will be hindered so long as it is unable to secure the necessary technical advisers.

In this connection we deem it worth while to point out that there is not in the whole United States a single engineering school at which can be obtained a first-rate course of instruction in gas engineering. We seldom argue in favor of specialization in engineering studies. As a rule we favor the broad and thorough foundation as the proper work for the engineering school. But if the gas companies declare that the engineer trained in their employment cannot honorably use his knowledge and experience in municipal service, the public may well ask where shall engineers be trained who can give their services to municipal work if not in the technical schools?

It is a notable fact that during the past week the foremost gas engineer in this country has been made President of one of our most noted engineering schools. In the addresses delivered at his inauguration much was made of the idea that the engineering schools are truly philanthropic enterprises. That they are not established merely to train youths to earn large salaries for themselves or larger dividends for their employers, but to work benefits that shall descend to the great mass of consumers and the great multitude of those who work with their hands.

We hold this to be a true conception. The millions poured into the endowment of engineering educational institutions can only achieve their highest results if the work done by their graduates as captains of industry results not merely in benefit to these men themselves and to their employers, but in benefits to mankind. To harness the great powers of Nature for the service of man was long ago defined as the task of the engineer.

But if we accept such a view of the engineer's work, is it not unworthy of the profession to declare a boycott against municipal gas works? We are not now arguing either for or against municipal ownership. We merely say that where a city desires to adopt this policy it ought to be able to find in the engineering profession competent advisers and managers for its work. If municipal ownership is indeed the public calamity which is sometimes claimed, the private owners of gas works should have nothing to fear from the experiment, and have no need to go to such lengths in their opposition.

It is well known that the new President of Stevens Institute has made large business sacrifices to accept the position. He has taken up the work as a philanthropic one, and deserves corresponding honor. We venture to hope that he will take a large view of the opportunities before him, and will improve his peculiar opportunity to establish at Stevens a course of instruction in gas engineering which shall be not merely the best in this country, but the best in the world. If this were done, and if gas engineering were set forth in text-books and recorded in technical literature to the same extent as is hydraulic engineering, for example, it could no longer be monopolized by private corporations, but would be at the service of all.

The contribution on the relations between engineers and contractors which appears on another page of this issue deserves attention, not alone because of the excellent ideas which are put forward in it, but because its author is speaking from a very large experience. While he modestly withholds his name from publication, we may say that he has had charge as Chief Engineer of railway construction work aggregating hundreds of miles, and has also been intimately connected with work from the contractor's side. He speaks, therefore, with authority; and when such a man criticises the time-honored system of adjusting the relations between engineers and contractors, it seems abundant proof that such criticism is deserved.

Where shall a beginning be made in order to bring the relations between engineers and contractors upon a proper basis, is the question with which our contributor concludes; and he answers this question with suggestions that more attention be paid to the matter of specifications and contracts in the engineering schools, that Chief Engineers instruct their subordinates in this matter, and that extra work or other departures from the contract be estimated, not by the Chief Engineer, but by an independent consulting engineer.

These suggestions are all good; but it seems to us that the chief remedy must be sought by going to the root of the matter and making clear to those who foot the bills that they are the losers in the long run when they attempt to shift the risk of loss upon the contractor. When corporation directors and municipal councillors are made to understand that the way to let work at a low price is to make it attractive to the contractor by eliminating all possible uncertainties and risks in connection with it, the rest of the reforms will be easy.

With the general principle of "home rule" for cities, so-called, most of those interested in good municipal government are in hearty sympathy; but by "home rule" is meant simply that the city should be left by the State to manage its own affairs to as great a degree as circumstances render best. It would not be possible, nor would it be desirable even if it were possible, for the State to wholly relinquish its power to protect the residents of cities in those rights which the constitutions of States and nation provide. Unfortunately, these limitations to the application of "home rule" are not generally understood. A notable illustration of this is given in a recent speech by Mayor Rose of Milwaukee. He is quoted by the Chicago "Record-Herald" as follows:

> I am opposed to charter government. Charter government is a relic of barbarism. Once granted by a king, it now is granted by the state to a municipality. The state has usurped sovereignty. I believe the people of a city are amply able to govern themselves.

The only way in which a city could attain that absolute independence of the State which Mayor Rose advocates, would be by its severance from the State and admission to the Union as a separate commonwealth. Even if so radical and revolutionary an act could be performed, there is absolutely no reason to suppose that it would result in any improvement in the character of the government. State governments as a whole have been far better than municipal governments in the United States. The city needs the country quite as much as the country needs the city. Until Chicago and New York and Philadelphia and St. Louis and our other great municipalities can point to a far better and longer record of good municipal administration, it would be the height of absurdity to set them up as independent States.

Mayor Rose objects to "charter government," but the only way in which a desirable measure of

"home rule" can be attained is through a grant of a charter by the State. A municipal government is a corporation, not a separate commonwealth; and its powers as a corporation are and must be limited to what the State grants. It is objected that this leads to continual interference with municipal government by State legislatures, and to "charter tinkering," so-called. So far as this is an evil it is a necessary one. If the contrary were the case,—if a State legislature could grant to a city a charter irrevocable and open to no amendment or alteration, it would be within the power of a single legislature to enact into law measures which no subsequent body would have the power to alter, no matter what the exigency. It needs no proof that even if it were legally possible for a State to confer upon a city a charter which should ever after be unalterable, it would be against public policy to do it.

The coroner's investigation of the Westfield collision has taken place since our last issue was published, and the ante-mortem statement of the express engineer differs somewhat from that first reported and commented on in our last week's issue. According to this statement, the engineer's view of the signals was obscured by the steam escaping from a leaky stuffing-box on one of the valve-stems, and a crack in the steam chest. He had to shut off steam to see the signals. After passing Cranford he had to fix the injector and missed one signal, as he "could not see what it was," and he saw the passenger train ahead only when within 60 ft. of it.

That the express engine was leaking considerable steam from the front end has been shown by other testimony. It appears that the engine was not the regular express engine, but was one taken at Trenton on the run from Philadelphia, the regular engine being taken off there on account of a hot box. While this escaping steam may very likely have interfered somewhat with the engineer's view, the fact that he was not maintaining a proper lookout is pretty well shown by the fact that he ran past not one block signal, but two, that he ignored the train order signal at Cranford and the crossing tender's stop signal near Westfield, and that he never saw the red taillights of the train ahead until he was within 60 ft. of it, although he was in plain view of it for eight miles. It must be remembered that the express train was running at high speed and that the locomotive was one with the cab placed high up over the center of the boiler in front of the firebox. Under such conditions steam would be blown backward as fast as it escaped and could hardly have risen so high as to interfere with the line of sight from the cab to the elevated signals, except, perhaps, for an instant in occasional puffs.

If it were actually the case that the cab was so enveloped in a cloud of steam that the engineer could not see ahead, he had no business to proceed at all. To run a train under such conditions would be practically equivalent to running it without an engineer in the cab.

Sifting and analyzing all the testimony, probably what actually happened was this: The engine did blow steam from the front end sufficient to bother the engineer somewhat in reading the low pot-signals when running through the yards at Jersey City, and very likely an occasional puff would cloud the front windows of the cab, and make it difficult to see through them. The engineer did not see the train order signal put out for him at the Cranford station, probably because he was not looking for it, it being unusual for a stop to be made by such a train for orders on a block-signaled road. He failed to make out the block signal beyond Cranford when he passed it, and under the rules he ought to have at once checked the speed of his train, and kept a sharp lookout for the next signal, ready to come to a full stop before reaching it if it stood at danger. But on this long straight stretch of road the track is usually clear, and engineers are accustomed to make up time; an injector just then demanded attention, and the engineer got down in the cab to fix it. While so engaged he passed the home signal standing at danger and the flagman waving his red lantern at the crossing, and when he again looked ahead he was close on the rear of the standing train.

The sum and substance of the cause of the disastrous Westfield collision, then, is disobedience to block signals by the engineer. The excuses for this disobedience are not important except as they shed light on the question, what can be done to make engineers implicitly obey signals, and never "take chances" when a signal is not seen or is seen only imperfectly. We see nothing better to be done than to continue the process of education and discipline—a process which doubtless needs to be applied to many subordinate operating officials, and perhaps to not a few higher ones, as well as to the men who compose our engine crews.

THE PROLIXITY OF SOME U. S. GEOLOGICAL SURVEY MONOGRAPHS.

That was a most sensible order of President Roosevelt's, issued a short time ago, directing those responsible for the preparation of Government publications to use more care in eliminating useless and irrelevant matter. No one who looks over many of the documents poured forth in such profusion from the Government Printing Office, can fail to be reminded of Gratiano's "two grains of wheat hid in two bushels of chaff. You shall seek all day ere you find them and when you have them they are not worth the search."

Thoughts like these come to us as we open the ponderous volumes issued as the annual report of the U. S. Geological Survey. Three of these volumes in the report just issued contain two thousand one hundred and fifteen quarto pages! And there is yet another volume to come.

Volume II of the Report is devoted to monographs on the ore deposits of the United States. It is a massive tome containing nearly 900 quarto pages—quite an encyclopedia in size. At first we marvel that in one short year so much that is new and worthy of being given to the world could have been discovered by the six or seven geologists whose names appear in the table of contents. As we read, we do not cease to marvel—we merely marvel from a different cause—at the flood of language which has so effectually buried all new facts under a deep "slickens" of words.

This volume ought to be a mine of geological discoveries—judging by its size; but excepting a few "claims," which we have "staked off" with our blue pencil, we fear that excavation will reveal only barren ground.

That this verbose treatment of the subject is wholly unnecessary is apparent; but such being the condition, let us seek an explanation of the condition.

To begin with, for whom are these monographs written? That is, what class of people is expected to read them? Judging by the introductory chapter by Professor Van Hise, on the Ozark Region, the expert mining engineer, or the geological chemist, is the one whom the writer is endeavoring to instruct, for the text is full of chemical formulas and expressions, such as "quaquaversal dips" and "peripheral monoclinal folds," which no non-expert reader would comprehend.

Passing to Mr. H. F. Bain's more detailed exposition of the Ozark deposits, we find at first an elementary treatment of the generally known theories of water circulation, such as might be used in a high school text-book of geology.

After a few score of pages of this sort of matter we find ourselves deep in an abstruse discussion of the chemical-precipitation-from-cold-water-theory of ore deposition.

In a word, we see no unity of purpose in this monograph. In one paragraph the writer is addressing the scientifically-trained man, in the next he is addressing the uneducated or immature. It seems almost as if the writer were trying to inveigle the ignorant prospector, or the no less ignorant capitalist into reading the monograph with the real purpose of burying him under a snow-slide of scientific language from which he will emerge with a profound respect for the author's scientific attainments.

It is self-evident that a scientific paper cannot be written which will be equally well suited to the tyro and the expert. The first thing to be determined, therefore, is for whom the paper is to be written, and having so determined, stick to that one line of writing.

There are two classes of readers interested in the geological work of the Government: the mining engineer or geologist, and the prospector or mine operator. Both are concerned with facts and with the deductions drawn therefrom, but any great amount of deductive reasoning or speculation will repel the practical miner, while a superabundance of elementary matter will repel the mining engineer or geologist. A paper written for the educated man should be brief and to the point, giving such valuable facts as have been newly discovered, and omitting all detailed rehashing of text-book matter. Long-winded speculations on ore formation have no rightful place in the Geological Report. No ore formation theory is as yet generally accepted, and until such a theory appears it is questionable, to say the least, whether theories upon the subject have a rightful place in a Government report.

Neither for the educated mining engineer nor the "practical" man is it desirable to cumber these reports with speculative theories. Both these classes of readers want facts, but it does not follow that either class wants all the facts which the geologists may collect. For example, it is a fact that:

> The Sunflower Mine is on the south side of Allyn Gulch, at an elevation of about 10,300 ft. The workings, consisting of a shaft and tunnel, are abandoned as inaccessible. Considerable work is reported to have been expended on a "contact" lying above those described in the Forest-Payroll mine.

The foregoing paragraph records facts, but of what earthly use these facts can ever be to any reader we do not see. It is by no means an isolated example of the recording of "facts" which give no information that will be of real value to the reader.

We are aware that this criticism may seem somewhat severe, since this tendency to pad technical literature by recording a great number of unimportant facts is one which is found nowadays almost everywhere. We call attention to it because it is a real and serious defect and one which in these days of voluminous scientific literature every writer ought to strive to overcome.

Finally, lest our criticism should seem unduly harsh, we may say that we single out this particular Government report merely by way of illustration and not at all because we suppose its authors to be more guilty of the crime of padding than their colleagues of former years, or than those who compile Government documents, in other departments. The authors of the Geological Survey reports are merely continuing a bad custom, one which has recently been made the subject of special condemnation by the President and one which ought to be radically reformed by scientists at least.

There are some of these dreary black-bound volumes issued from Washington, which nobody reads or is expected to read, although their publication is made compulsory by law. The appropriation for publication of the Geological Survey reports, however, is made on the supposition that the work done by the Survey ought to be published and made available for the practical use of scientists, engineers and others interested in the mineral industry. It is not the waste of Governments funds in the publication of useless matter that is so much to be deplored as the fact that the useless matter makes the useful matter less available and valuable to those for whom it is intended and so defeats the very purpose which the publication is designed to serve.

LETTERS TO THE EDITOR.

Some Suggestions on Concrete-Steel Construction.

Sir: Having done considerable designing of concrete-steel work in connection with a most reliable contractor doing that class of work, Mr. Sewell's article on the subject of concrete-slab construction, in Engineering News of Jan. 29, 1903, proved especially interesting to me; it is one of the best that has appeared in the technical press on its subject.

We (the above contractor and myself) have always considered that it is preferable to have an excess of concrete in compression over that of the corresponding strength of iron in tension.

The stirrup theory has been practiced in the United States for several years, setting the stirrups so that the tops lean toward the bearing ends of each beam or at right angles with the line of fracture from shearing. The

strain in the stirrups may be readily calculated, and as the total load-producing shear decreases toward the center of the beam, the center stirrup will be of a lighter cross-section and those at the ends heavier.

From the illustrations in the article referred to it seems that the twist given to the steel bars is very slight, certainly not being 25% of what it should be; we therefore have a very long wedge, which, when tension is put in the floor, results in a "split" fracture along the horizontal plane of the bars. The bars in the sections of floor tested were not placed properly in the concrete to resist the shearing stress to the best advantage, nor to properly take the tension at the required point.

We believe Mr. Sewell is correct in his theory that concrete and steel will take the place of skeleton-steel construction in the near future, and that it is equal, if not superior to, said construction. We must expect, however, that it will take time to educate engineers, architects, contractors, artisans, laborers and owners up to the work and to the proper concrete that should be used with steel in its various conditions and shapes.

The adhesion of the concrete to the steel bar we consider has no value in concrete-steel construction, and therefore do not make use of it in calculations. My friend has never found steel, which had been imbedded in cement-concrete for several years, to show continuous adhesion of the concrete to the bar; not over 5% of the surface of the bars had cement sticking to them. Steel, however, can be treated in such a manner as to give perfect adhesion of the concrete, but the method to be employed would be slow and very expensive. The contractor of whom I speak has yet to learn of any of his construction failing from either its rated load or from loads much in excess of the same, with which some of his floors have been loaded at various times. This statement covers a range of loading of from 100 to 1000 lbs. per sq. ft. or more.

In my opinion testing a single section of floor, that is, between two beams, will give much poorer results than testing two or more sections in a finished piece of work. We know that continuous beams over more than two supports will carry a greater load than a beam simply supported at each end.

Another matter previously referred to which influences to a marked degree the strength of concrete-steel work is the mixture proportions of cement and aggregate, and what material that aggregate is—for example, whether cinder, gravel or trap rock broken small.

Taking everything in consideration, I have great faith in "the man behind the gun," who knows intuitively every move to make and how best to do it; he is especially needed if we want concrete-steel work done its very best.

Yours very truly, W. W. Christie.

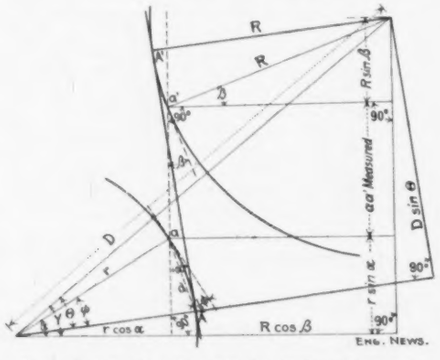
Paterson, N. J., Feb. 4, 1903.

Another Method of Finding a Tangent to Two Circles.

Sir: In several of your recent issues there have been a number of different methods of connecting two curves by a tangent. In 1898, I had occasion to connect two curves run from opposite directions, and finding little or no information in the field books, worked out the following formulas:

Let a and a′ be any two points on the curves; draw a straight line through them. Measure a a′; also measure the angles α and β made by tangents to the circles with the line a a′ prolonged. Then, referring to Fig. 1,

$$\tan Y = \frac{R \sin \beta + a a' + r \sin \alpha}{R \cos \beta \pm r \cos \alpha}; \quad (1)$$



Method of Joining Two Circles With a Tangent

$$D = \frac{R \cos \beta \pm r \cos \alpha}{\cos Y}; \quad (2)$$

$$\cos \theta = \frac{R \pm r}{D}; \quad (3)$$

$$\phi = \alpha \mp Y \pm \theta; \quad (4)$$

$$d = 2 r \sin \tfrac{1}{2} \phi = a A; \quad (5)$$

$$A A' = D \sin \theta. \quad (6)$$

Where the $\mp$ or $\pm$ signs occur in the above equations, use the upper sign when the centers of the circles are on opposite sides of the tangent, and use the lower sign when centers are on the same side of the tangent.

Trusting some in the profession may find this method of use, I am,

Yours truly, Henry A. Wolcott.

49 Pearl St., Hartford, Conn., Jan. 3, 1903.

Uniform Tests of Cement.—Correction.

Sir: In the last issue of the Engineering News there appears the report of the Committee on Uniform Tests of Cement of the American Society of Civil Engineers. In the last sentence of the first paragraph, under Chemical Analysis, of this report, the Committee, through an oversight, omitted the words "for Portland cement" before the word magnesia. The sentence in question should read: "While not recommending a definite limit for these impurities, the Committee would suggest that the most recent and reliable evidence appears to indicate that, for Portland cement, magnesia to the amount of 5% and sulphuric anhydride to the amount of 1.75% may safely be considered harmless." On behalf of the Committee,

Richard L. Humphrey, Secretary.

Philadelphia, Pa., Feb. 3, 1903.

An Instance of Rapid Wear of an Elevator Wire Rope Subjected to Reversed Stresses.

Sir: The article in Engineering News, of Jan. 15, on "Rules for Working Loads of Wire Elevator Ropes" is of much interest to the writer, as he has lately had a case in point where the proper relation between drums and cable was not maintained.

There are two elevators installed, each with 42-in. drums. Elevator No. 1 has a 30-in. vibrator sheave, while elevator No. 2 has a 42-in. vibrator sheave. Manufacturers guarantee these elevators for a live load lift of 2,500 lbs., at a speed of 250 ft. per min. There are two ¾-in. lifting cables each of a guaranteed tensile strength of 19,000 lbs., two ¾-in. drum counterweight cables of the same tensile strength, and two ⅝-in. car counterweight cables. The elevators were opened for service April, 1901; in November of the same year the drum

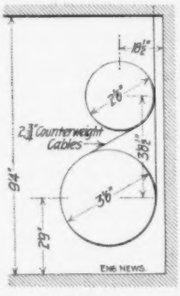


Fig. 1. Old Drum and Sheave of Elevator No. 1.

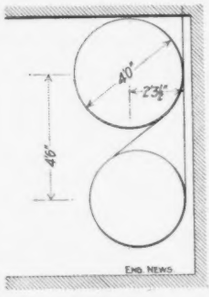


Fig. 3. Old Drum and New Sheave of Elevator No. 1.

counterweight cables on elevator No. 1 were found to be in such bad condition that they had to be replaced. In September, 1902, this second pair of cables had to be replaced by a third pair. All the other cables in this elevator are in good condition, showing hardly any signs of wear. On elevator No. 2 the original cables are still in use, and all in good condition except the drum counterweight cables which are showing signs of giving out, some of the wires have worn and cracked. The accompanying sketches show relation of drums and vibrator sheaves, Fig. 1 representing the original layout of elevator No. 1, and Fig. 2 that of elevator No. 2. When trouble first arose with the cables, the outfit was examined for cause of short life, and it was found that the groove in the 30-in. sheave originally installed was by some mistake for a ⅝-in. rope instead of ¾-in. rope, so it was thought that this was the whole cause of the trouble. The machine was a standard one of a reliable company, so it did not occur to any one at that time to question the general design. The grooves referred to were corrected before the second cables were put in, Nov., 1901, yet the comparatively short life of these cables also showed that the cause of the trouble had not been removed. The question of the size of rope and drums was then taken up, and the stresses due to bending over the drum were calculated from exactly the same formula and assumptions as in the article in your issue of Jan. 15 referred to above, including the assumption as to increased radius of curvature being offset by friction in cable throwing greater stress in some wires. The results were certainly startling. Using same notation and formula we get:

$$P = \frac{E\,d'}{2\,R} = \frac{27{,}000{,}000 \times 0.05}{30} = 45{,}000 \text{ lbs. per sq. in.};$$

d′ was 0.05-in. by actual gage. The 114 wires in the cable would have a total area of 0.224 sq. ins., thus giving a stress in the cable equivalent to 45,000 × 0.224 = 10,000 lbs. The counterweight weighs approximately 2,400 lbs, or 1,200 lbs. per cable. Thus the total stress in the cable would be 11,200 lbs., giving a factor of safety of

$$\frac{19{,}000}{11{,}200} = 1.7.$$

The drum is 42-in., so the stress due to bending would be 7,200 lbs., and the total stress 8,400 lbs., giving a factor of safety of 2.27. This stress is still too high, but it would be impossible to change drums without obtaining a new machine. It was decided, however, to put in as large a vibrator sheave as possible (see Fig. 3). Owing to several unfortunate delays this is only now being done, which means that the cable has already run four months

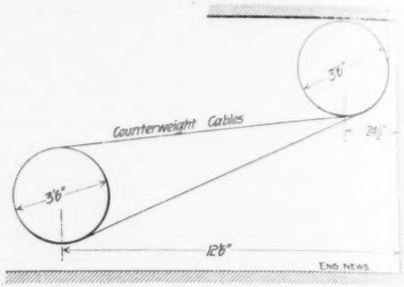


Fig. 2. Drum and Sheave of Elevator No. 2.

under adverse conditions, and consequently it will be impossible to determine just what improvement the larger sheave has made.

The drum counterweight cables are the only ones where the radius of curvature reverses. It is evident from the good condition of the other cables that the change in stresses from compression to tension bears a very important part in the rapid deterioration of the cables, and it was for that reason a 48-in. vibrator sheave was determined on.

Theoretically a ⅝-in. rope would give a factor of safety of about 2.54, which is larger than that obtained with the ¾-in. rope. Would it be advisable to change to the smaller size? If the theoretical equation used above gives results conforming to practice, how long may the other cables be expected to last when the factor of safety is about 2.3, and the stresses run up to 37,000 lbs. per sq. in. in material of ultimate strength of 85,000 lbs.

Yours truly, G. M. Campbell.

Electrical Engineer, Pittsburg & Lake Erie R. R. Co., Pittsburg, Pa., Jan. 22, 1903.

Some Possible Substitutes for the Metric System as a World System of Weights and Measures.

Sir: Regarding metric measurements attention may well be drawn to the fact that common English usage employs only the foot, the pound and the gallon. For great distances miles and hundreds of miles and for great areas acres and thousands of acres are spoken of, and for weights the ton and thousands of tons obtain. Many articles formerly sold by bulk in bushel measures are now sold by the pound—vegetables and grains, for example; even oil has a tendency to be sold by the pound instead of by the gallon, and in the West 75 lbs. coal oil is occasionally seen to denote a case of two square tins.

In domestic measures the metric system proved a failure, and at the present time a "half-kilo," or metric pound, is employed, which, by chance, just equals the old Belgian pound, or 2.1 English pounds. The disadvantage in the metric system is that a meter, say 40 ins., is too long, and its next division, the decimeter, say 4 ins., is too short, while a foot can be used in field or office with equal facility. Moreover, our mile section system of land survey precludes the practical adoption of hectares and kilometers. For scientific purposes in the laboratory centimeters and milligrammes are suitable, but for field work we might as well begin to use the old-fashioned yard and the hand, as employed for measuring horses. It may be convenient to remember that a decimeter is to all intents and purposes "a hand," or 4 ins., and a centimeter is the width of the little finger nail. If the hands are placed to enclose a cubical space by bending the fingers square to the palms and superimposing the right upon the left then the space fairly represents a liter, and that bulk of water would weigh a kilogramme, or 2.2 lbs. English.

Two arrangements for standard world measures were possible instead of adopting the metric system in entirety: One was nearly hit upon by the British commission that examined into weights and measures about 1860, and after much labor took a cubic foot of water to weigh 1,000 ounces. Now a cubic foot is just 1,000 cubic tenths, as employed by American engineers, so a cubic tenth would have contained an ounce and weighed an ounce. A 20-ounce pound would then have allowed of quartering as well as decimal division, and a ton of 2,000 of these 20-ounce pounds would have equalled 2,500 lbs. of the present weight.

A second method of standardizing measures would have been to accept the meter, but divide it into 3 metric feet,

each 13 odd inches long, then divide this metric foot into tenths and hundredths. The Canadian and United States measure used by engineers, viz., the foot, tenth and hundredth and the 100-ft. chain, is the best arrangement known, and far to be preferred to a metric rod for leveling and a 30-meter chain.

It might be suggested that a metric pound or 2.1 lbs. English could be adopted, while our foot would be universally used and bulk measure would disappear entirely. We might gladly accept the centigrade thermometer in this connection.

Another improvement would be Flamerion's time system, whereby January 1st would be zero, leaving 364 days, or exactly 52 weeks, to form a working year, and when leap-years occurred we would have two January zeros to celebrate. The year would thus always commence on Monday if desired.

I remain yours sincerely, C. R. Coutlee,
M. Can. Soc. C. E.

Inns of Court Building, Vancouver, B. C., Jan. 25, 1903.

Another Reply to Mr. Porter's Letter Against the Metric System.

Sir: The author of the letter against the metric system printed in your issue of Dec. 25 makes some statements which deserve a reply.

He says: "The Committee of the American Society of Mechanical Engineers . . . contemptuously dismisses the bill now before Congress." Reports of the last annual meeting state that the Society declined to approve the report of the committee, and referred the whole subject to a new committee, two of the members of which advocated the system at that meeting.

He further says: "The promoters of this measure were very probably excused on the ground of ignorance." The National Board of Trade of the United States does not wish to plead ignorance for their strong advocacy of the metric system, nor does the American Institute of Electrical Engineers. The charge of ignorance is an unworthy one to make against such men as have for years filled the positions of Secretary of the Treasury, Secretary of State, and the officers in charge of the standard of weights and measures who after the most careful study of the situation as regards weights and measures in the world, without exception favor the adoption of the metric system.

The author arraigns the metric system by saying: "Its pretension to be scientific is absurd." I would ask whether the author's opinion on this point is sufficient to counterbalance the repeated resolutions of such representative scientific societies as the American, British and International Associations for the Advancement of Science, and the National Academy of Science of the United States? The present metric standards were prepared after years of research and experiment in coöperation with the scientific men officially representing twenty nations. I am not aware that the standards of any other system of weights and measures were prepared with the coöperation of even two nations. The eminence of the founders of the metric system, as well as the unanimity of the scientific world in adopting it as the universal language of weights and measures in scientific work is convincing evidence that the claim of the system to be scientific is not altogether groundless.

He further says: "The metric system is still proclaimed to be the grand universal scientific system of weights and measures." This claim is true and needs no comment. However, when he speaks of the "merely theoretical minds" who might be "dazzled by its brilliant pretensions" I would like to ask if he includes among these "merely theoretical minds" such practical men as Andrew Carnegie, who says that the adoption of the metric "system is one of the steps forward which the race is bound to take sooner or later" and that "our present system inherited from Britain is unworthy an intelligent nation of to-day"? Does he include such men as Thomas A. Edison, who said: "Everything in the shape of instruments manufactured or designed by me is made by the metric system"; or the American Waltham Watch Co., which for 30 years has employed the metric system "as being greatly superior in convenience in the manufacture of watches."

A few of the others who are "dazzled by the brilliant pretensions" of the metric system are the Association of American Steel Manufacturers (resolution passed unanimously), the American Institute of Architects, the National Association of Builders, the American Society of Civil Engineers (resolution of 1877), American Medical Association, New England Cotton Manufacturers' Association. These are certainly not the kind of organizations likely to be deceived by mere pretensions.

Again, the simplicity of the metric system seems to bewilder the author when he says that the "metric system is absurd in confounding together weights and measures, things which are entirely dissimilar and unrelated." He refers to the fact that the measures of length, area, volume, capacity and weight are all derived from the single unit, the meter, so that a cubic decimeter of cold water weighs a kilogram and measures a liter. He may be interested in knowing that James Watt, the inventor of the steam engine, was the first to propose such an interrelation. He did it from purely practical considerations, and in this he was seconded heartily by the other scientific practical men of his day. If these are "the blunders of schemers," what can we hope from novices in weights and measures?

The author makes a gross misstatement which is so palpable that it scarcely needs mention. He says: "Physicists deal with minute quantities and do not measure, but only weigh." This is untrue, for exact measurement of length is the basis of all precise physical investigation. The science of physics has developed the art of precision in length measures more than any other line of human endeavor, so that an optician is enabled by purely "physical methods" to grind a true plane surface to a maximum error of less than the one-millionth of an inch; and with the interferometer, using the wave length of light as the unit, distances not greater than one two-millionth of an inch can be readily measured. Surely physics *does measure* and with a precision unknown to the most accurate gage-maker in the world. As to physicists dealing only with "minute quantities," attention need only be called to a recent study of the dynamics of the universe published in the "Philosophical Magazine" by the world's foremost physicist, Lord Kelvin. In this article the metric system is alone used, and the author discusses the dynamics of a particle and the dynamics of a universe of a thousand million suns, using the weight of the sun as a unit. Here is one instance to show that the metric system is "equally suited to everything; things *large* as well as small." Lord Kelvin, in addition to being the foremost physicist, is also one of the greatest instrument makers and the man who made possible the practical use of the Transatlantic cable. Such men are not "mere theorists."

That "metricists use three units for length" is incorrect. There is but one unit, the meter; the others are the decimal multiples and submultiples. The author probably overlooks the fact that the prefix "milli" in the word "milli-meter" means "one-thousandth part" and if he wishes to use the latter term he may do so without confusion. Surely if as he says three terms suffice, something is gained by the metric system over our ordinary measures of length which comprise some sixteen different terms, none of which are related decimally, three of the fifteen different ratios being fractional.

The fourth objection that the use of "continual bisection" is forbidden, is an error. Who has forbidden it? Anyone has the privilege of saying "two and one hundred and seventeen one-hundred-and-twenty-eighths" if he chooses, which is an extreme case. However, most modern mechanicians prefer to use the decimals, even when using inches. The fact is that our decimal coinage still permits the use of halves and quarters, with facility—and this is as far as it has been found convenient to carry binary subdivision of the dollar. Modern machine shop practice is almost universally decimalizing its lowest unit for ease in computation and accuracy in gaging, but this side by side with the division into sixty-fourths, thirty-seconds, sixteenths, etc., only multiplies the confusion. Besides, who would think of wishing to use "sixty-fourths of a dollar" after having made use of our simple decimal coinage?

The author makes the statement that the "proper field of the decimal system of division is in the expression of very small or fractional quantities." But it happens that all expressions in the old system below 1 in. are fractional—and aside from this our whole arithmetic is decimal—and it would be as illogical to say that our decimal arithmetic was adapted only to the expression of small numbers. As a matter of experience it has been stated by competent mathematicians that the economy of the decimal ratio in computation is at least 50%.

The author alludes to the "absurdity of writing '38 ft.' as '11,558 millimeters.'" Would a person who wishes a pound of sugar ask for 7,000 grains, or would a person order 14,000,000 grains of coal? The absurdity is the same in either case. In other countries 38 meters would be expressed not as 38,000 millimeters, but as 38 meters just as in the English system we say 38 ft. instead of 456 ins.

The writer says that "the metricists want uniformity," which is true—but he continues "in the English system of linear measure we have uniformity." How about the mile, the perch, the chain, the foot, the link, the line, and the point—all of which are ambiguous terms. The perch may be 24¾ cu. ft. stone measure, or 5½ yds. surveyor's measure. The mile may be the U. S. land mile of 5,280 English feet, or the nautical mile of 1.158 statute miles, or any of the dozen or so continental miles varying from our own up to the Greek mile of about 6 1-5 U. S. miles. The chain may be the 66-ft. surveyor's chain, or the 100-ft. engineer's chain, decimally divided. The lumber measure of the "foot" may be 1,728 cu. ins. for the timber foot, 144 cu. ins. for the board foot, 16 cu. ft. for the cord foot. The link may be the decimally divided foot of the engineer in which each division is six-fifths of an inch, or the surveyor's link of 7.92 ins., with the division into 0.792 in. The "line" may be the .085-in. or the .0833-in., and the point may be .008-in. or .0138-in. Even the symbols for the foot (') and the inch (") are ambiguous, being used for minutes and seconds of arc, angular measure. The list might be extended, but hardly shows that our linear measures are in a state of "unapproachable excellence."

The critic says "our system of linear weights and measures is interwoven with the lives of this people." So were the spinning wheel, the tallow candle, the flint box, and the hour glass—but this is scarcely an argument for their retention in the twentieth century.

It seems evident that the author represents those conservatives, who always challenge new and progressive ideas, but who, with faces turned toward the past, fail to see the coming of those great reforms which are rapidly uniting the world into closer comity. It is to be hoped that ignorance may not longer block the extension of the international metric system to all industries and all countries, and the attainment of the ideal of practical metrologists for centuries of a universal, simple decimal system of weights and measures with but one unit from which all other terms are derived.

Very truly yours,

A. T. Hubbard, Mgr. Improved Cummings Filter Co.
1129 Arch St., Philadelphia, Pa., Jan. 10, 1903.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF MISSOURI.—Prof. R. H. Richards, of the Massachusetts Institute of Technology, has just completed a short course of lectures, delivered here, on ore-dressing, in which he set forth the results of his exhaustive study on this subject.

UNIVERSITY OF MICHIGAN.—The new engineering building, which is being erected at a cost of $140,000, will be equipped with a naval testing tank, a compressed air plant, hydraulic laboratory, steam and electric plants, and cold-storage room. The tank for testing ship models which is nearly completed is in the basement of the north wing. It is 300 ft. long, 22 ft. wide, and 10 ft. deep. Connected with it is a dry-dock capable of holding a model 10 ft. long. This tank will be used for experiments concerning the shapes and sizes of boats, and the different kinds of propellers.

Besides the above there will be rooms for testing instruments, computing, calibrating, drawing, recitation rooms, and instructors' rooms.

CORNELL UNIVERSITY.—A letter from Prof. H. Wade Hibbard announces the gift of a locomotive to the University by the Baldwin Locomotive Works. The letter follows:

Sir: The Baldwin Locomotive Works has recently offered to present to the Railway School of Sibley College a laboratory locomotive of the Vauclain-de Glehn type, especially built to plans to be agreed upon by the Baldwin Works and myself. The gift will not be consummated until a building and a testing machine are provided for.

The locomotive will be a four-cylinder balanced-compound like the engine built for the Plant System, but with four track wheels and four driving wheels. The boiler will be designed to carry up to 300 lbs. gage pressure. When the locomotive is run at this pressure the entire weight of the locomotive can be thrown upon the driving wheels by means of a pneumatic cylinder at the rear connected to an anchor in the foundation. When this traction increaser is not used the engine will run at 200 lbs. gage pressure. It is intended to be very easily convertible into a perfectly balanced two-cylinder simple engine by the removal of the two high pressure cylinder bushings and a change in the valves. The details of the engine have not as yet been worked out, but are being figured. No work at all has as yet been done on the designing of a testing machine, awaiting the development of the design of the locomotive, its weight, power, wheelbase, etc.

When the plans of testing machine and building are completed and estimates available, we shall call upon the friends of Cornell for assistance.

I would add that every fall a series of locomotive tests is regularly carried on for our Railway Seniors through the kindness of the Delaware, Lackawanna & Western Railroad upon that portion of the road which comes into Ithaca. I have named these "Instruction Tests," as they are primarily intended to instruct our railway students in the methods of locomotive testing on the road. Each cylinder has two indicators with short straight pipes, the indicator reducing rig is of the pendulum or singular triangle type, geometrically perfect, practically rigid and light, and entirely satisfactory. The coal is weighed into bags, water is metered betwen tank and injector, hydraulic dynamometer drawbar used, steam chest diagrams taken; we use steam-dryness calorimeters in dome and steam chest, smokebox, vacuum gage, take the smokebox temperature, use the Boyer speed recorder, driver stroke counter and recorder, air pump stroke counter and recorder; and we make the various calibrations of dynamometer, tank, water meter, boiler, blower, safety valve, air pump, valve setting, cylinder clearances, etc. The students themselves do the work of rigging up the locomotive for test and stripping it ready for replacing in its regular service. It is not intended that these annual instruction tests should be omitted after we have a laboratory locomotive. Towards the end of the senior year a

number of our railway seniors and graduates usually make thesis tests of locomotives for different railroads in the East. The students are in full responsible charge without assistance from the faculty. The coming spring, among other tests of railway equipment, there will be one of the Baltimore & Ohio locomotive upon the Royal Blue limited train between Philadelphia and Washington.

UNIFORM MUNICIPAL ACCOUNTING in Massachusetts was recommended by Governor Bates in his annual message. He trusts that the legislature "may find it possible to take favorable action along this line," and suggests that supervision of the work should be entrusted to the State Auditor.

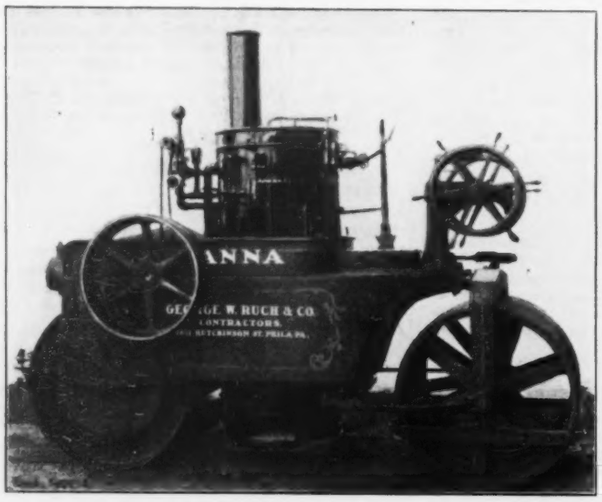


FIG. 1. SIDE VIEW OF STEAM ROAD ROLLER, WITH VERTICAL BOILER. Julian Scholl & Co., New York City, Makers.

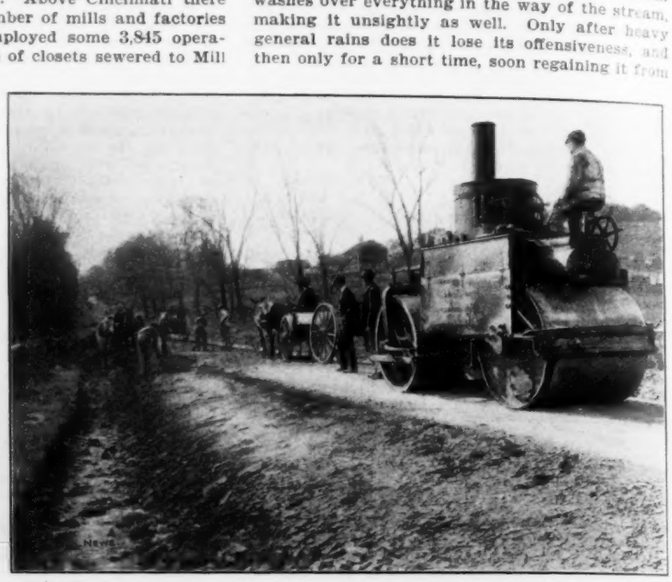


FIG. 2. VIEW OF "UNIVERSAL" ROLLER AT WORK ON A NEW YORK STATE ROAD.

A SANITARY SURVEY OF MILL CREEK VALLEY, AT AND NEAR CINCINNATI, O.

A sanitary survey of Mill Creek Valley, at Cincinnati, O., with a view of determining the sources of pollution which have caused this stream to be probably the foulest in the State, has just been completed by Mr. Benj. H. Flynn, Jun. Am. Soc. C. E., Engineer of the Ohio State Board of Health. This investigation was undertaken with the view of presenting a report to the legislature in which action will be urged toward such an act as will enable the corporations interested to combine in the preparation of some general plan that will solve the problem for the entire valley. Owing to the number and location of the cities and villages interested, separate action would be useless or very expensive, while combined action can abate the nuisance with but comparatively little expense.

As the Ohio River seems to be dedicated to the public as a general drainage line, though still used for public water supplies, it is thought that the problem can be solved by an intercepting sewer through which all the sewage proper and objectionable manufacturing wastes can be carried to the Ohio River, where there is sufficient water to dispose of it by dilution. The channel of Mill Creek can then be rectified for the care of the storm flows of the sewers and other less objectionable drainage.

Mill Creek has a drainage area of 168 square miles, on which there was a population of 125,298 in 1900. This area includes portions of Butler, Hamilton, and a strip of Warren Co., and in it are all or portions of some eighteen incorporated cities and villages, and more than twenty smaller unincorporated places. The population of the incorporated towns ranges from 360 to 79,423, the portion of Cincinnati within the watershed. The urban population is 109,235, and the rural population is 16,063.

All of the incorporated towns with the exception of Mt. Airy and Mt. Healthy have a system of public water supply, but of the 16 towns supplied with water only Cincinnati, Evanston and Norwood have anything like sewerage systems. Evanston and Norwood, with a total population of 4,900 within the drainage area, have some 1,675 people making use of their sewer systems. Cincinnati has 79,423 people in the drainage area, of whom it is estimated that 30,000 have the use of the numerous lines of sewers.

There are five convents, two infirmaries, one asylum, one hospital, and two penal institutions, with a total population of 5,080, the sewage from which is sent practically direct to the main stream or its branches. Above Cincinnati there are located a large number of mills and factories in which there are employed some 3,845 operatives who have the use of closets sewered to Mill Creek. Altogether then it is estimated that Mill Creek receives above Cincinnati the sewage from 10,220 people, and that the city adds to this some 31,200, making the total figure something over 41,000.

In addition to the sewage the stream receives the manufacturing waste from some eighty industrial establishments, not counting minor ones, scattered along the stream. Above Cincinnati the waste is sent to the stream through private drains and sewers as a rule, but in the latter the regular sewers are usually used.

The waste from the starch works, paper mills, soap works, distilleries, breweries, and slaughter houses is especially objectionable, and from Lockland down the pollution is continuous and persistent, allowing no chance for recovery from its effects.

Scattered over the drainage area there are 111 dairies, supporting over 2,000 cows. The drainage from many of these places is very offensive, as large heaps of manure are allowed to accumulate in such places as will allow it to be washed into the streams with each heavy rain.

From Lockland to its confluence with the Ohio, Mill Creek is an open sewer, foul smelling nearly all the time, and full of black, putrid mud which washes over everything in the way of the stream, making it unsightly as well. Only after heavy general rains does it lose its offensiveness, and then only for a short time, soon regaining it from the load of filth sent to it. Its condition is greatly improved over what it would otherwise be by the addition of water from the Miami and Erie Canal which parallels it for much of its length, crossing it twice, at Lockland and just above Carthage. We are indebted to Mr. Flynn for the information given.

A NEW TYPE OF STEAM ROLLER.

In building macadam roads the English type of steam roller, with horizontal boiler, has been used almost exclusively in this country, but recently a macadam roller with a vertical boiler has been placed upon the market by the firm of Julian Scholl & Co., of 126 Liberty St., New York city. This machine is called by the manufacturers the "Universal" Roller. Fig. 1 shows a side view of one of the smaller rollers of this type. It will be observed that, like the steam rollers used in asphalt paving work, the new roller has but two wheels, which are of equal width; unlike the as-

FIG. 4. "UNIVERSAL" ROLLER WITH GROOVED ROLL FOR EMBANKMENT WORK.

phalt rollers, however, both the front and rear rolls of the new roller are of about the same diameter. This allows the machine to surmount obstacles and in connection with very powerful gearing, to do rough work with ease. There are, however, many points of difference between the "Universal" roller and the well-known asphalt rollers. The most radical departure is in the method of firing the boiler. There is a hopper at the top of the boiler with a central pipe leading down through the boiler to the fire-box. This hopper is filled with coal, and is provided with a shaker, by means of which the engine-driver can shake down more coal as necessity requires, so that he need not leave his seat to fire. This device is said to work well with anthracite or coke, but with soft coal the engine-driver would of necessity have to descend occasionally to break up the clinker, although the shaking grates with which this machine is provided almost entirely obviate this.

The water tank surrounds the boiler, and on top of this tank bags of coal may be carried in addition to the supply of coal in the hopper. It will be seen from the following table that the water and coal capacity is adequate for half a day's run:

Weight of roller in tons.....	5	7	10
Nominal horse-power of engines.....	18	25	40
Coal capacity in lbs.	300	400	500
Water capacity in gallons.....	175	225	275
Length over all in ft.	12	13	16
Total height in ft.....	9	10	10½
Height with stack, swung back, in ft..	7½	8	8½
Working steam pressure, lbs.....	125	125	125

The roller is provided with double horizontal engines. There is a pulley wheel which may be used to run a stone crusher, or the like, if it is desired to use the roller for stationary work of that character. It should be remarked that the engines are encased and up away from the ground so that they are well protected from dust; and being mounted on a separate engine frame they transmit no stresses to the boiler shell.

It is claimed for the vertical boiler, as compared with a horizontal boiler, that there is much less danger of burning out crown sheets and tubes when working on grades.

The steering gear is made for either power or hand operation, and the roller is made not only in the sizes shown in the foregoing table, but in all sizes from 3 up to 12 tons; the heavier sizes for macadam work, and for rolling earth embankments, and the lighter sizes for rolling lawns, golf courses, paths, and the like. Fig. 2 shows a 7-ton roller in use on a New York State macadam road. It may be observed in this connection that such a roller will effectively compress a subgrade without becoming stalled, which frequently happens with the narrow rear-wheeled rollers commonly used; on the other hand the wide roller is apt to bridge over small soft spots. Fig. 3 shows the roller hauling a sort of harrow or tool for scarifying or picking up an old macadam surface. No picks are usually provided for the wheels of the "Universal" steam roller, but this harrow or scarifier serves the same purpose, and avoids racking and straining the roller by the use of picks. Aitkin, in his valuable treatise on "Road-Making," says that as early as 1817 a harrow was patented to scarify the uneven parts of a road, and he goes on to describe the scarifiers in use in England:

FIG. 3. "UNIVERSAL" ROLLER DRAWING SCARIFIER USED TO BREAK UP OLD MACADAM SURFACE.

> In districts where macadam scarifiers have been introduced and practically applied it is considered to be an indispensable adjunct in connection with steam rolling. As it is usually attached to the engine, but can be detached in a few minutes if necessary, it is available at a moment's notice; this is a convenient arrangement when the repairs on the road are carried out on the patching system.

He then describes the several English scarifiers, giving the cost of breaking up old macadam by their use, as compared with scarifying by hand. With wages at 9 cts. an hour he has found the cost of scarifying by hand to be 3½ cts. per sq. yd., as compared with ½-ct. per sq. yd., where 150 to 300 sq. yds. per hour are scarified to a depth of 4 ins. by a roller-drawn scarifier.

An important application of the "Universal" roller is to the work of compacting earth embankments for earth dams, reservoir walls, etc., where grooved rollers are necessary. Fig. 4 shows one of these rollers at work on the new filter beds for the Philadelphia water supply. It will be seen that the steering roller is grooved, while the main or driving roller has cross strips fastened to its face, which not only prevent the roller from slipping when at work in greasy clay, but help to compact and render homogeneous the earth under the roller. It is claimed that this roller will do work on an earth embankment more rapidly, cheaply and effectively than a horse roller.

THE NEW ORE DRESSING LABORATORY AT COLUMBIA UNIVERSITY, NEW YORK CITY.

Laboratory work grows in favor all the time in all kinds of scientific instruction. Text-books are of undoubted value, but the student finds an experiment performed by himself far more impressive than any amount of instruction in words however clearly presented.

In schools of mining engineering, one of the great difficulties which has been met in teaching ore dressing by the laboratory method has been the difficulty of keeping full sized frue vanners, jigs and the like in continuous operation for several hours. For example, if a ton of pulp is available for practice work by the students, in a comparatively few minutes it has passed over the vanner, and before the student has had time to really begin the adjustments of the machine he is confronted with the delightful (?) task of pulp shoveling and transportation.

If the student visits mills in full operation he may watch and study machinery in perfect adjustment, but he gains no knowledge of how to make the adjustments that are necessary whenever a new plant is installed.

The student may be taught the scientific principles of ore classification by means of small and inexpensive apparatus, but in no way can be learn how to handle full sized machines, except by having full sized machines continuously supplied with material at his disposal.

To make continuous running of full sized machines possible, Prof. Henry S. Munroe, of Columbia University, New York, has designed an ingenious and exceedingly effective laboratory plant. After the crushed ore has been treated on jigs, vanners, tables, hydraulic classifiers and the like, it passes down into a sub-basement where it enters one of the ordinary mechanical feeding machines, which serves not only as an automatic feeder, but as a small supply reservoir. The material is thence fed into a centrifugal pump which elevates it back to the upper floor, at the same time thoroughly mixing it. Thus with half a ton or so of crushed ore, any ore classifier may be kept running continuously without attention for any desired length of time. The students first learn the principles underlying ore dressing in a laboratory provided with small tables, glass hydraulic classifiers, etc., that is they here learn the science of ore dressing. Then passing into the large ore dressing laboratory they learn the art of adjusting and handling full sized classifiers. So far as we know, this is the only laboratory of the kind in existence where a continuous supply of crushed material is made available for tests, by using the material over and over again. In designing this admirable laboratory and in working out its details, Prof. Munroe has added greatly to the effectiveness of teaching the art of ore dressing by laboratory methods. But he has done more. He has thus made it possible to test a small amount of any given ore and determine what machines are best adapted to separating the mineral. A mining engineer can thus test half a ton of rock in a most thorough manner, saving perhaps thousands of dollars in avoiding the purchase of ill-adapted apparatus. Hitherto, due to the expense of mining and transporting any considerable quantity or ore (generally from an almost inaccessible prospect), engineers have generally guessed at the kind of machines to use, with the usual consequences of any guessing process. This laboratory, therefore, marks a great advance not only in methods of teaching students, but also in the testing of new ores to determine the best method for their mechanical treatment under conditions exactly like those to which they will later be subjected in practice.

COMPUTING THE STRENGTH OF CONCRETE-STEEL BEAMS.

By Edwin Thacher,* M. Am. Soc. C. E.

Prof. W. K. Hatt read at the last annual meeting of the American Society for Testing Materials, a paper giving tests on concrete-steel beams, and a comparison of same with his theory for such beams (Eng. News, July 17, 1902). This is a subject in which the writer takes considerable interest, and his conclusions after quite a careful consideration of the paper may be of interest to engineers in general.

The tests appear to have been made with more than usual care, and are undoubtedly reliable. It is to be regretted, however, that Prof. Hatt did not use some one of a half-dozen or more well-known brands of Portland cement that has been in successful use for several years, and on which the results of tests can be foretold with a fair degree of certainty. For the cement used, briquettes of neat cement gave the same strength in seven days as in three months, and briquettes of one cement and three sand broke at 412 lbs. in seven days, having more than double the strength usually specified.

Compressive tests were made on cylinders 8 ins. in diameter and 12 ins. long. The crushing strength was 2,880 lbs. per sq. in. in nine days, and 2,575 lbs. per sq. in. in 14 days. According to reliable tests made at Watertown Arsenal we would expect a strength of about 1,500 lbs. in nine days, and about 1,700 lbs. in 14 days. The modulus of elasticity in compression of 1 : 2 : 4 stone concrete under a pressure of 1,500 lbs. per sq. in. was 3,940,000 lbs. in nine days, and 3,680,000 lbs. in 14 days. From tests made at Watertown Arsenal on concrete of the same mixture and under the same pressure, in which well-known brands of American and German Portland cement were used, the average modulus was 1,350,000 lbs. in seven days, and 1,460,000 lbs. in 30 days, or about four-tenths as much as Prof. Hatt found.

It is evident that constants used in formulas for concrete steel beams derived from tests on cement and concrete, giving such abnormal results as above quoted, will not necessarily apply to beams in which a different brand of cement is used. Of the 22 tests made by Prof. Hatt, ten were on concrete-steel beams of 1 : 2 : 4 stone concrete from 25 to 28 days old, and the balance on plain concrete or concrete-steel beams from 6 to 17 days old. The former have much the greater value. Prof. Hatt has applied his theory to only eight of his tests, so these alone will be considered. The object of the writer in working up these tests was to compare the actual load producing first crack with the theoretical load given by certain formulas proposed by him, and published in the Transactions of the Association of Civil Engineers of Cornell University, Vol. 10, 1902. The load producing first crack is considered the breaking load, as the beam is then practically destroyed. Complete failure, however, does not usually occur until the load has been increased from 10% to 25%. This can be considered, if desired, as adding that much to the factor of safety. The formulas above referred to are as follows:

$$x = \left[\sqrt{\left\{2A \cdot \frac{E_s}{E_c}\right\} d + \left\{A \cdot \frac{E_s}{E_c}\right\}^2} - A \cdot \frac{E_s}{E_c}\right] \quad (7)$$

$$W = \frac{S\,b}{9\,l}\left\{\frac{E_c}{E_s} \cdot \frac{x^3}{y} + 3\,A\,y\right\}. \quad (9)$$

$$C = S \cdot \frac{E_c}{E_s} \cdot \frac{x}{y}. \quad (2)$$

In these formulas:

E_s = modulus of elasticity of metal;
E_c = modulus of elasticity of concrete, under pressure of from 1,000 to 2,000 lbs. per sq. in.;
S = ultimate tensile strength of metal per sq.in. = test specimen + 10%;
C = compression in concrete per sq. in.;
C_1 = probable crushing strength of concrete per sq. in.;
W = load in pounds at center of beam producing first crack;
A = area of metal for 1 in. width of beam;
l = clear span in feet = 6.67;
x, y, d, h, and b (Fig. 1) are in inches:

If the value of C exceeds the probable crushing strength of the concrete C_1, reduce the value of w by the ratio of $\frac{C_1}{C}$ to provide for failure in the concrete.

*Park Row Building, New York city.

TABLE I.—Showing Comparison of Strength of Concrete-Steel Beams as Determined by Actual Tests and by Hatt's and Thacher's Formulas.

No. of test.	Age of test beam, days.	d.	A.	Results obtained by Prof. Hatt.—W—Actual.*	Theory.	Variation of actual from estimated strength.	Results by formulas (2), (7) and (9)—Using constants found by Prof. Hatt.—x.	y.	$E_s \div E_c$	W × C strength	Variation, actual C from estimated strength	Using value of E_c found at Watertown Arsenal.—x.	y.	$E_s \div E_c$	W × C strength	Variation actual C from estimated strength
4	25	6.0	0.0751	5,240	4,925	+ 6.5%	2.14	3.86	7.9	5,450	— 4.0%	3.0	3.0	20.0	7,180	— 27.0%
5	28	6.0	.0751	5,240	4,925	+ 6.5%	2.14	3.86	7.9	5,450	— 4.0%	3.0	3.0	20.0	7,180	— 27.0%
6	25	6.0	.1534	5,900	7,123	— 15.8%	2.79	3.21	7.9	6,760	— 11.3%	3.73	2.27	20.0	8,500	— 29.8%
7	27	6.0	.1534	6,740	7,123	— 5.4%	2.79	3.21	7.9	6,760	— 0.4%	3.73	2.27	20.0	8,500	— 20.7%
8	25	7.0	.0751	7,490	6,232	+ 20.0%	2.38	4.62	7.9	6,910	+ 8.4%	3.33	3.67	20.0	9,400	— 20.3%
9	23	7.0	.0751	6,740	6,232	+ 8.0%	2.38	4.62	7.9	6,910	— 2.5%	3.33	3.67	20.0	9,400	— 28.4%
10	27	7.0	.1534	10,240	9,680	+ 6.0%	3.08	3.92	7.9	8,825	+ 16.0%	4.17	2.83	20.0	11,200	— 8.5%
11	25	7.0	.1534	10,240	9,680	+ 6.0%	3.08	3.92	7.9	8,825	+ 16.0%	4.17	2.83	20.0	11,200	— 8.5%
Average						+ 4.0%					+ 2.3%					— 21.2%

*Half weight of beam has been added.

Data: E_s = 29,000,000; E_c = 3,680,000; S = 55,000; C = 2,400; l = 6.67. E_s = 29,000,000; E_c = 1,460,000; S = 55,000; C = 2,400; l = 6.67.

The data given by Prof. Hatt for use in the above formulas are not complete, so some assumptions will have to be made.

The ultimate strength of the 7-16-in. and ⅝-in. common wrought-iron rods used in the beams is not given, but will be assumed at 50,000 lbs. per sq. in. The yield point found by Prof. Hatt, however, corresponds to what might be expected from medium steel. The eight tests considered were made on beams from 25 to 30 days old, while the compressive strength and modulus of elasticity in compression were found on cylinders 9 days and 14 days old. As the strength in 14 days was less than in 9 days, it will be reasonable to assume that the strength in 25 or 30 days will be somewhat less still, and it will be taken at 2,400 lbs. per sq. in., which is the mean strength given by reliable tests made on 12-in. cubes at Watertown Arsenal.

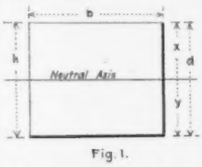


Fig. 1.

Table I. explains itself. Prof. Hatt's theory considers the modulus of elasticity of concrete, both in tension and compression, and the strength of concrete both in tension and compression. The strength of a concrete-steel beam depends on the brand of cement used, on the composition, age and manipulation of the concrete, as well as on the character, location, and amount of metal reinforcement. Allowing Prof. Hatt's theory to be strictly correct, it appears to the writer a hopeless undertaking to assume correct constants to suit all of the varying conditions of calculation, and besides its application requires more time and labor than the average calculating engineer can afford to give it. It is not claimed that formulas (2), (7) and (9) are strictly correct, and they may be considered to a certain extent empirical. A guess is as good as anything if you guess right, and an empirical formula is as good as anything if it gives correct results, and measured by this standard the writer believes the formulas proposed will compare favorably with any other formulas for the purpose now in use, besides requiring much less labor in application.

A comparison of the results found by test, and given by formulas (2), (7) and (9), has been made for the sets of tests given in Table II.

The above tests, made at different localities and by different men, taken as a whole, give a mean variation between actual and estimated strength of about 1-80 of 1%, or practically zero, which is certainly somewhat remarkable. The tests cover a variation of length to depth of from 6.0 to 22.2; a variation in ultimate strength of metal used from 50,000 lbs. to 100,000 lbs. per sq. in.; a variation in area of metal used from 0.31% to 3.9%; a variation in mixture of concrete from 1 : 2 broken brick to 1 : 2 : 4 and 1 : 3 : 6 stone concrete, and a variation in age of concrete from 23 days to 90 days. No theory can be established by any one set of experiments, and the writer believes that no purely rational theory will ever succeed, or be widely adopted. The conditions to be met are too widely varying, and the work too complex. Experiments made in France in 1902 have shown that in concrete-steel specimens the shrinkage of concrete set in air, caused a compression in the imbedded steel of from 6,500 lbs. to 14,200 lbs. per sq. in., and a high tensile stress in the concrete. As this stress is variable, it is evidently impossible for any formulas to fit all cases. Referring to Table I., it will be seen that for the eight tests for which Prof. Hatt compared actual and theoretical strength, there is a maximum variation of 20%, and a mean variation of 4%. By the formulas proposed by the writer, in which the same constants have been used so far as known, there is a maximum variation of 16%, and a mean variation of 2.3%, the result being a little in favor of the simpler formulas. It will also be noticed that using in formulas (2), (7) and (9) the modulus of elasticity found by the Watertown tests, the same that has been used for comparison with all other sets of tests given, the actual strength is 21.2% less than calculated, from which it can be inferred that if a cement of normal quality had been used, the actual strength found by Prof. Hatt would have been 23.5% higher; also that if the modulus of elasticity of the concrete is increased 2.5 times, everything else remaining the same, the strength of the beam will be diminished 23.5%.

A study of the load deflection diagrams given in Prof. Hatt's paper is interesting and instructive. They give the point at which first crack occurred in all cases, and in no case is there any change in the line at this point, or until the breaking point was reached, which appears to show that the beams were in the same condition before they cracked as afterwards, and as the concrete could take no tension after cracking, the writer fails to see how it could have taken any before the crack occurred, and if this is true, the strength of concrete in tension, and its modulus of elasticity in tension, should not be considered in formulas for concrete-steel beams, as has not been done in formulas (2), (7) and (9). The beams were certainly in a very different condition from those tested at Zanesville, in all of which the deflection increased suddenly and very rapidly after the first crack appeared. The writer is much inclined to believe that this difference in behavior was due to a movement of the rods in the concrete in Prof. Hatt's beams, although no such movement was observed. As there was no mechanical

TABLE II.—Showing Comparison of Strengths of Concrete-Steel Beams, Obtained by Actual Tests and by Thacher's Formulas.

No. of tests.	Size of beam tested. l.	d.	b.	12 l / d	Variation between actual and estimated strength. Maximum.	Mean.	Test. Where made.	By whom made.
3	11.5	10.0	5.0	13.8	1.3%	0.0%	Zanesville, O.	Onward Bates and E. Thacher.
3	6.0	3.25	10.0	22.2	3.7%	+ 0.6%	Zanesville, O.	Onward Bates and E. Thacher.
9	5.0	10.0	12.0	6.0	14.0%	— 1.2%	London, England.	Prof. David Kirkaldy.
7*	11.0	10.0	8.0	13.2	13.1%	— 1.4%	Mass. Inst. of Tech.	Leonard C. Wason.
8	6.67	6 & 7	8.0	13.3-11.4	16.0%	+ 2.3%	Purdue University.	Prof. W. K. Hatt.

Mean from 30 tests = — 0.013%.

*Five other tests were made which were not satisfactory, and have been omitted.

connection between the bars and the concrete, any reduction in area of the bar due to stress must necessarily pull the bars away from the concrete in which they were imbedded, destroying adhesion, and diminishing friction. This will commence at the center, where the stress is greatest, and as the load is increased, gradually extend towards the ends, causing less stiffness and greater deflection. Assuming that formulas (2), (7) and (9) are correct, and judged by the results given in Table II., they are nearly so, and assuming further that the strength of the steel in tension should be equal to the strength of the concrete in compression, which the writer believes will give the most economic design, these formulas, when used for the design of beams, can be greatly simplified, as is shown in Table III., which gives formulas for bending moment, load at center, and load per sq. ft., producing first crack, and depth required for any load or length of beam; also the area of steel required per lineal inch in width of beam. These formulas are in the same form, and as simple as formulas for wooden beams, any one of which can be solved with a slide rule in a small fraction of a minute. The formulas are worked out for 1 : 2 : 4 concrete one month and six months old, and for steel having an ultimate strength of 50,000 lbs., 60,000 lbs., 70,000 lbs., 80,000 lbs., and 90,000 lbs. per sq. in., but can be extended to any extent desired. It is the practice of the writer to give the concrete a certain factor of safety at the end of one month, and to give the steel the same factor of safety as the concrete at the end of six months, as it is evident that if there was not an excess of steel in one month, there would be a deficiency after the concrete gained its full strength. For example, to design a slab 6 ft. long, using 60,000-lb. steel, for a total load of 400 lbs. per sq. ft., that shall have a factor of safety of four in one month, but in which the tensile strength of the steel shall be equal to the compressive strength of the concrete after six months.

$$d = \sqrt{\frac{l^2 w^1}{883}} = \sqrt{\frac{6.0^2 \times 400}{883}} = 3.92 \text{ ins.},$$

or h = 5 ins.,

if center of bars are 1.08 ins. from bottom of concrete,

$$A = \frac{d}{90} = \frac{3.92}{90} = .0435 \text{ sq. in.}$$

Using Thacher patent bars, having original diameter of ⅝-in., area = .276, weight per foot = .94 lbs., distance c. to c. bars = $\frac{.276}{.0435} = 6.35$ ins. It can be shown from Table III. that if the strength of the steel in tension is equal to the strength of the concrete in compression, the strength of the beam for a unit of area of steel is in proportion to the ultimate strength of the steel; in other words, the higher the steel the greater the economy. An inspection of the table will show also that for the same depth of beam, the milder the steel the greater the strength and stiffness of the beam. If the strength of the steel in tension exceeds the strength of the concrete in compression, there will be a gain in strength due to the lower position of the neutral axis; the percentage of gain may be governed to some extent by the depth, but probably to no great extent. The probable gain in strength by doubling the amount of reinforcement can be most conveniently determined from Table I., giving Prof. Hatt's experiments, in which for Nos. 6, 7, 10, and 11 about double the amount of metal was used as for Nos. 4, 5, 8, and 9, or about 2% and 1%, respectively.

By Prof. Hatt's experiments,

$$\frac{5,900 + 6,740 + 10,240 + 10,240}{5,240 + 5,240 + 7,490 + 6,740} = 1.34 \text{ or } 34\% \text{ gain.}$$

By Prof. Hatt's theory,

$$\frac{(7,123 + 9,680)}{(4,925 + 6,232)} \times 2 = 1.51, \text{ or } 51\% \text{ gain.}$$

By formulas (2), (7), and (9) E_c, as found by Prof. Hatt),

$$\frac{(6,760 + 8,825)}{(5,450 + 6,910)} \times 2 = 1.26, \text{ or } 26\% \text{ gain.}$$

By formulas (2), (7), and (9) E_c, as found at Watertown,

$$\frac{(8,500 + 11,200)}{(7,180 + 9,400)} \times 2 = 1.19, \text{ or } 19\% \text{ gain.}$$

The probable gain in strength of beam therefore by an excess of 100% in reinforcement will be about 30% for high modulus concrete such as was used by Prof. Hatt, and about 20% when concrete having an average modulus is used.

Although the formulas given in Table III., judging from the results given in Table II., are highly satisfactory, it is possible, and in fact quite probable, that future experiments will show that the constants should be changed somewhat, for the writer is not fully satisfied with any of the tests given in Table II., for the following reasons: The tests at Zanesville were made in very cold weather, and the specimens were frozen, which may have affected the result. The tests made by Prof. Kirkaldy were made 25 years ago, and the strength of metal is in doubt. In the tests made at the Massachusetts Institute of Technology several of the bars slipped in the concrete, and it is not known whether last deflection given in report of tests means first crack or not, and in the tests made by Prof. Hatt, the specimen tests on cement and concrete gave results unusual, and unsatisfactory. The writer is satisfied, however, that the formulas given in Table III. are correct in form, or that in concrete-steel beams the amount of reinforcement should bear a constant relation to the depth of beam, and that when this relation is maintained the strength of the beam, when supported at the ends and loaded at center, will vary directly with the square of the depth, and inversely with the length.

M. Considere found that (1 : 3) Portland cement mortar, in which was imbedded steel wires having an elastic limit of 54,000 lbs., had a maximum stretch of 1-500, and that when iron or soft steel was imbedded, the stretch was 1-1,000. Other experimenters have observed a stretch as high as 1-1,000 in Portland cement concrete, but the writer has been unable to find any recorded tests giving higher results for concrete; this corresponds to an elastic limit of 30,000 lbs. per sq. in. in steel. Prof. Hatt found a maximum stretch of 1-1,140, which corresponds to an elestic limit of 25,400 lbs. per sq. in. in the iron. The yield point given by Prof. Hatt was probably by drop of beam, commonly called elastic limit, but somewhat above the true elastic limit. If the maximum stretch of concrete cannot exceed 1-1,000, steel having an elastic limit of 30,000, or an ultimate strength of 60,000 lbs., will be sufficient to develop that stretch. M. Considere states also that concrete can stand, without crushing, a reduction in length of from 1-1,400 to 1-1,000, and that its elastic limit, so far as concrete can have an elastic limit, is probably about 0.6 the crushing strength.

The grade of steel to use in concrete-steel beams is an important question. Steel rails are quoted lower in the Philadelphia market than Bessemer or Open-Hearth billets, so if there is any difference it is probably in favor of high steel, particularly if old rails are bought at scrap value and re-rolled into bars. The modulus of elasticity is

TABLE III.—GIVING FORMULAS FOR CALCULATING CONCRETE-STEEL BEAMS (E_s = 30,000,000).

Concrete.				Steel.										
Mixture.	Age.	C ult.	E_c.	Test specimen per sq. in.	S.	$\frac{S}{C}$	$\frac{E_s}{E_c}$	x.	y.	A.	Ultimate bending moment, ft.-lbs. for beam 1-in. wide, M.	Weight at center producing first crack, beam 1-in. wide, W.	Uniformly distributed load: ultimate. Per sq. ft., w^1.	Uniformly distributed load: ultimate. Depth required for w^1, d.
1 : 2 : 4	1 month.	2,400	1,460,000	50,000	55,000	22.9	20.55	0.473 d	0.527 d	$\frac{d}{97}$	38.90 d^2	$\frac{159.2\ d^3}{l}$	$\frac{3,820\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{3,820}}$
				60,000	66,000	27.5	20.55	.428 d	.572 d	$\frac{d}{128}$	36.80 d^2	$\frac{147.2\ d^3}{l}$	$\frac{3,533\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{3,533}}$
				70,000	77,000	32.1	20.55	.390 d	.610 d	$\frac{d}{164}$	33.87 d^2	$\frac{135.5\ d^3}{l}$	$\frac{3,252\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{3,252}}$
				80,000	88,000	36.7	20.55	.359 d	.641 d	$\frac{d}{204}$	31.52 d^2	$\frac{126.1\ d^3}{l}$	$\frac{3,026\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{3,026}}$
				90,000	99,000	41.3	20.55	.333 d	.667 d	$\frac{d}{248}$	29.52 d^2	$\frac{118.1\ d^3}{l}$	$\frac{2,834\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{2,834}}$
1 : 2 : 4	6 months.	3,700	2,580,000	50,000	55,000	14.9	11.63	.438 d	.562 d	$\frac{d}{68}$	57.52 d^2	$\frac{230.1\ d^3}{l}$	$\frac{5,522\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{5,522}}$
				60,000	66,000	17.8	11.63	.395 d	.605 d	$\frac{d}{90}$	53.07 d^2	$\frac{212.3\ d^3}{l}$	$\frac{5,095\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{5,095}}$
				70,000	77,000	20.8	11.63	.359 d	.641 d	$\frac{d}{116}$	48.75 d^2	$\frac{195.0\ d^3}{l}$	$\frac{4,680\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{4,680}}$
				80,000	88,000	23.8	11.63	.328 d	.672 d	$\frac{d}{145}$	45.02 d^2	$\frac{180.1\ d^3}{l}$	$\frac{4,322\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{4,322}}$
				90,000	99,000	26.7	11.63	.304 d	.696 d	$\frac{d}{176}$	42.00 d^2	$\frac{168.0\ d^3}{l}$	$\frac{4,032\ d^2}{l^2}$	$\sqrt{\frac{l^2 w^1}{4,032}}$

$$y = \frac{d}{\left[\frac{C}{S} \cdot \frac{E_s}{E_c} + 1\right]} \quad (3), \qquad A = \frac{d}{2\left\{\frac{S}{C} + \left[\frac{S}{C}\right]^2 \frac{E_c}{E_s}\right\}} \quad (6), \qquad M = \frac{S}{36}\left\{\frac{E_c}{E_s} \cdot \frac{x^3}{y} + 3 A y\right\} \quad (8), \qquad w_1 = \frac{S b}{4.5 l^2}\left\{\frac{E_c}{E_s} \cdot \frac{x^3}{y} + 3 A y\right\} \quad (10)$$

about the same for all grades of steel, and consequently the stretch per unit of area is about the same. Mild steel requires greater area, but gives greater stiffness than high steel. High steel is most economical, provided it is a proper and safe material to use. Fifteen years ago steel having an ultimate strength as high as 84,000 lbs. per sq. in. was used in bridge trusses. At the present time the writer does not know of any specification allowing steel higher than 70,000 lbs. per sq. in. to be used for bridges and structural steel work. The writer has consulted eleven of the latest specifications for bridges, and finds a minimum strength of 52,000 lbs. per sq. in., and a maximum strength of 68,000 lbs. per sq. in. specified. A steel testing from 60,000 lbs. to 62,000 lbs. per sq. in. would satisfy all of them, and according to present indications it will be but a short time before only one grade of steel will be adopted for all bridges and structural work in the United States. This will undoubtedly result in quicker deliveries, and a more reliable and uniform product. The writer can see no good reason why a very high steel should be used for concrete-steel construction, including arch and girder bridges, and bridge floors, and a very low steel be used for all other bridge and structural work. High steel bars may be produced by using a steel high in carbon, and usually also high in phosphorus, worked hot, or by using a milder steel worked cold beyond its elastic limit, or first stage of rupture. The writer is of the opinion that no steel higher than medium, having a mean strength of about 64,000 lbs. per sq. in. should be used for concrete-steel work, and that the quality should conform to standard practice for other work, and that the additional weight and cost of this grade of steel is fully compensated for by its greater uniformity and safety.

A GRAPHICAL METHOD FOR THE CALIBRATION OF IRREGULAR VESSELS.

By Arnold Emch.*

1. By some one interested in the Boulder oil field I have been asked for a method for calibrating a horizontal cylindrical oil-tank, with spherical segments at the ends. I judge that the most practical method for this purpose is experimental. Nevertheless, the question may be raised how this can be done theoretically. The answer, of course, is very simple. Suppose the lowest point of the vessel touches the XY-plane (horizontal) and that the equation of the interior surface be

$$z = f(x, y). \qquad (1)$$

By integration, or other methods, the area A of each horizontal section may be calculated as a function of z, say $A = f(z)$, so that the volume V is

$$V = \int_0^h f(z)\, dz, \qquad (2)$$

where h is the distance of the highest point from the lowest point (vertically).

If we desire to calibrate the vessel with a gallons as a unit, V being expressed in cubic feet, then a gallons $= a \times 0.1337$ cu. ft.; and the whole vessel contains $\frac{V}{a \times 0.1337} = b$ given units. Taking n of these units, the number of cubic feet in the vessel is $n\,(a \times 0.1337)$. In order to find the corresponding distance z of the level from the lowest point, we have to compute $\int_0^z f(z)\, dz = g(z)$ in cubic feet, so that

$$n\,(a \times 0.1337). = g(z.) \qquad (3)$$

This equation solved for z, gives for z a function of n, say

$$z = \phi(n). \qquad (4)$$

Of course, there may be several solutions for z, and we have to choose that solution which is compatible with the given data. Having found (4) in this manner, for every value of n we can calculate the corresponding value for z. Thus, the problem is theoretically solved.

For compound vessels the integration of (2) and the solution of (3) become so complicated that for such cases the method is of little practical use. I propose, therefore, the following graphical method which I establish in a general form:

2. Assume the same interior surface $z = f(x, y)$ (this may resolve into different surfaces) and divide the vertical distance h into equal units of c feet each, beginning at the lowest point. Designate the corresponding distances of the division-points from the bottom by $z_1, z_2, z_3, \ldots, z_k, \ldots$, so that $z_k = k \cdot c$ feet. Through these division-points pass horizontal planes and calculate the areas of their sections by a planimeter or otherwise (the sections must first be drawn) and designate these by A_k, $k = 1, 2, 3, \ldots$ (unit = square feet). Then plot the points (z_k, A_k), $k = 1, 2, 3, \ldots$, the z_k's as the abscissas and the A_k's as ordinates. Connect these points by a continuous curve, Fig. 1, which shows the relation between the areas of horizontal sections and their distances from the origin. It is now clear that the area between the co-ordinates z_k and A_k and the curve represents the volume $g(z_k)$ in cubic feet, in the vessel up to the height z_k. Computing all these volumes $g(z_1)$, $g(z_2)$, $g(z_3)$, . . . , by the planimeter, and considering them as abscissas in a new co-ordinate system in which the z_k's are the ordinates, a new curve, Fig. 2, is obtained. In the plotting of the curves in Figs. 1 and 2, feet are supposed to be used as units for linear, quadratic and cubic measure. In an actual drawing nothing of the result is lost by plotting properly to another scale, for instance, 1 inch, or 1 centimeter to the foot. If we now lay off from o equal parts, each measuring $a \times 0.1337$ feet, then the corresponding values of z give us exactly the distances on h, marking off equal volumes in terms of a units.

The method sketched here ought to prove valuable when applied to irregular reservoirs.

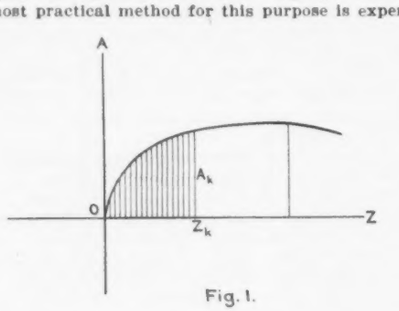


Fig. 1.

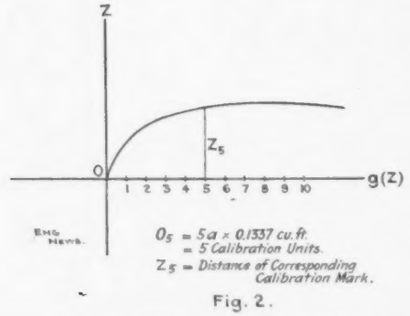


Fig. 2.

THE SEPTIC TANK for the sewage disposal system of Wheaton, Ill., is to be 22 × 58 ft., 8 ft. deep, with a longitudinal division wall and a transverse division wall resting upon transverse steel channels 3 ft. 9 ins. above the bottom. These will divide the tank into four sections, in each of which will be two sets of baffle boards reaching to 4 ft. 3 ins. below the top. The south wall will be 15 ins. lower than the others, and capped with a 6 × 6-in. steel angle to form a discharging weir. In the north wall will be two 15-in. sewer pipe inlets, leading from a common valve chamber, so that sewage can be admitted to either half of the tank. The tank will be of concrete, composed of 1 part Portland cement, 2 parts sand, and 4 parts limestone and gravel, in sizes of ¼-in. to 1½ ins. All surfaces will have a finishing coat ½-in. thick, of 1 part Portland cement to 2½ parts sand. At the east side will be a sludge well 8 ft. 6 ins. square, connected with the tanks by 24-in. pipe. The tank will be contained within a brick building 60 × 22 ft., with a wing 25 × 8½ ft. for the sludge well and engine room.

CURRENT METER RATINGS AND OBSERVATIONS BY THE U. S. IRRIGATION INVESTIGATIONS DEPARTMENT.

In the "Report of Irrigation Investigations for 1900,"* Mr. Clarence T. Johnston, Assistant Chief of Irrigation Investigations, of Cheyenne, Wyo., describes the method employed in rating current meters and computing the results obtained. We reprint that section of the report herewith and append a description of field methods of reading current meters, the latter having been prepared at our request by Mr. Johnston. The reprint is as follows:

Electric current meters have been generally employed during the season of 1900. Current meters depend for their usefulness on the care with which they are rated, and as the rating of the best meters changes somewhat with use, a station has been established at Cheyenne for this purpose.

RATING STATION.

Current-meter measurements depend largely for their accuracy on a determination of the relation between the rate of revolution of the wheel of the instrument and the velocity of flowing water in which it is held. It will be found that not only do meters of different designs vary in their rating, but that meters of like design seldom revolve at the same speed when immersed in currents having equal velocity. This variation is due to minute mechanical defects and differences which cannot be overcome in construction, making it necessary that each meter have a separate rating. As meters are used their rating gradually changes. This change, of course, varies with the style of the meter, with the extent of use, and with the care exercised in handling the instrument.

A large part of the field work carried on by the irrigation investigations requires the use of the current meter. To make the results of the measurements trustworthy, a rating station has been established, where all meters are tested and accurately rated before being sent to observers in the field. They are again rated when returned to the Cheyenne office, for the purpose of noting whether any change has occurred during the period they have been in use.

Permission was obtained from the city authorities of Cheyenne to establish a rating station at the city reservoir on Crow Creek. The reservoir is a cement-lined excavation, rectangular in shape, 120 ft. wide by 240 ft. long. At the points marked A and B, Fig. 1, two pulleys were erected, each 10 ft. in circumference. Passing around these pulleys and diagonally across the reservoir is an endless wire. A boat, the plan and elevation of which are also shown, is attached to the endless-belt wire, so that when the driving pulley at A is turned it is drawn diagonally across the reservoir. The current meter is attached to the forward end of the boat, in a vertical position, with the meter wheel 12 or 14 ins. below the surface of the water.

Nearly all of the meters used by observers in the field are of the electric pattern, and the rating apparatus has been designed for this class of instrument. A heavy insulated wire is stretched from the supports of the two pulleys before referred to, on which a brass trolley connected with one of the terminals of the meter slides. Near the center of the wire the insulation has been removed for a distance of 200 ft. As soon as the trolley runs off of the insulation on to this wire the electric circuit is completed at each revolution of the meter wheel, ringing a bell at the driving pulley. The boat carrying the meter is drawn at any desired speed through the still water, and the time occupied in making the run is recorded, together with the number of revolutions of the meter wheel in that period. Knowing the length of the run to be 200 ft., the relation between the rate of revolution of the meter wheel and velocity of the boat can easily be computed. These observations having been obtained, an equation is found which represents a mean curve passing through as many of the points as possible. The notes can be reduced either graphically or analytically.

GRAPHICAL METHOD.—From the observations taken at the rating station, the velocity of the meter or boat in feet per second and the corresponding number of revolutions per second made by the meter wheel are computed. These results are platted, the revolutions of the meter wheel per second as abscisse and the velocity in feet

TABLE I. Comparison of meters Nos. 68 and 81.

Revolutions per second	Velocity in feet per second. Meter No. 68.	Meter No. 81.
0.05	0.19	0.35
.25	.75	.75
.50	1.45	1.40
.75	2.14	2.06
1.0	2.84	2.72
1.25	3.54	3.38
1.50	4.24	4.04
2.0	5.63	5.36
2.50	7.03	6.68

*Devoted to that part of the work of the U. S. Department of Agriculture which is under the charge of Mr. Elwood Mead, M. Am. Soc. C. E.

*Assistant Professor of Pure and Applied Mathematics, University of Colorado, Boulder, Colo.

per second as ordinates. Ordinarily the points thus platted lie on or near a straight line, which is to be located. This is conveniently done in the following manner: Through a point whose co-ordinates are an average of those already platted and conforming to all as nearly as possible a straight line is drawn. Fig. 2 shows the line obtained for two Department meters of the same pattern, Nos 68 and 81. It indicates how differently the two meters behave in the same current. It will also be noticed that between velocities of 0.7 and 0.9 ft. per sec. the curves are identical, but both above and below this section the variation is considerable.

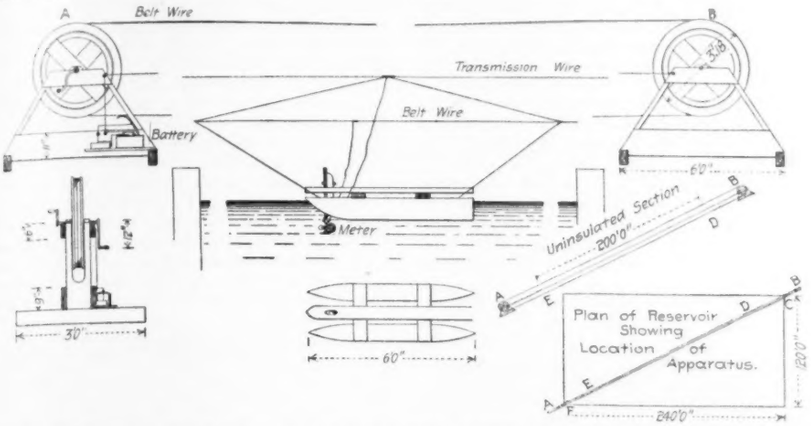


FIG. 1. APPARATUS USED AT U. S. CURRENT METER RATING STATION, CHEYENNE, WYO.

Table I. shows this variation and indicates that below a speed of 0.25 revs. per sec. meter No. 81 runs the easier, while above this point the opposite is true.

There are two methods by which the rating table may be derived from the curve. One consists in reading from it direct the velocities per second corresponding to the number of revolutions per second; in the other, the rating table is derived from the equation of the curve. This being a straight line, its equation is of this form:

$$Y = MX + C,$$

in which Y and X are the variable quantities, viz, velocity of flow in feet per second, and revolutions of the meter wheel per second, respectively; M is the tangent of the angle which the platted line makes with the axis of X, and C is the distance from the origin to the point at which this platted line crosses the axis of Y, otherwise known as the intercept on the axis of Y. This value of C is determined directly by measurement. The value of M is determined by calculation from average values of X and Y at various points on the curve. From this equation the rating table is computed, giving the velocity for each change of 0.05 revolution of the meter wheel per second. This graphical method is the one most commonly used by the office in the preparation of rating tables for the various current meters.

ANALYTICAL METHOD.—This method is known as the rigid method, the equation being derived by mathematical calculation. The solution is sometimes aided by using the method of least squares. This process, however, is quite complicated, and it is extremely doubtful if the results obtained are more accurate than those obtained by the method just described.

TABLE II. Rating observations, Department meter No. 81.—July 6, 1900.

Time of passage. (Seconds.)	Revolutions of meter.	Velocity of meter. (Feet per second.)	Revolutions of meter per second.
374	67	0.53	0.18
217	67	.92	.31
121	72	1.65	.60
91	72	2.20	.79
81.5	72	2.45	.88
43.5	71	4.65	1.64
Oct. 4, 1900, after being used one season and before being cleaned.			
490	42	0.41	0.09
434	49	.46	.11
288	60	.69	.21
234	67	.85	.29
134	72	1.49	.54
107	73	1.87	.68
102	71	1.96	.70
101	74	1.98	.73
66	75	3.03	1.14
51	74	3.92	1.45
42	74	4.76	1.76
35	74	5.71	2.11
33	74	6.06	2.24
31	76	6.45	2.45
Oct. 4, 1900, after being cleaned.			
654	14	0.31	0.02
447	36	.45	.08
203	67	.96	.32
144	71	1.39	.49
103	74	1.94	.72
63	74	3.17	1.17
51	74	3.92	1.45
40	74	5.0	1.85
34	75	5.88	2.21

As an example of the method pursued in deducting a rating equation and its subsequent use in making computations of the velocity of flowing water, a specific case will be cited, that of Department meter No. 81. It is an electric meter of recent pattern, and is especially adapted for the measurement of small streams, canals and ditches. The first rating of this meter was made July 6, 1900. The observations taken at this date are shown in the upper division of Table II. The figures in the two columns on the left are the ones taken at the time of rating. The figures in the two columns at the right are derived from these.

The distance traveled by the meter was in all cases 200 ft. The velocity with which the meter travels per second is the distance traveled divided by the time, or as in the first observation, $200 \div 374 = .53$ (ft. per sec.). The number of revolutions of the meter wheel per second is found by dividing the total number of revolutions by the number of seconds consumed in making the trip, or as in the first observation, $67 \div 374 = .18$ (rev. per sec.). The velocity with which the meter travels and the number of revolutions of the meter wheel per second having been determined for each observation, the next step is the platting of these results on co-ordinate paper, with the velocities in feet per second as ordinates and with the number of revolutions of the meter wheel per second as abscissæ. The diagram shows the rating curve for this meter.

The first division of Table II. gives the observations taken on July 6, while the meter was new, and before it had been used. These points are represented on the co-ordinate paper by crosses inclosed in small circles. The observations in the second division of the table were taken after the meter had been in use about two months and before it had been cleaned. These observations are represented on the co-ordinate paper by small circular dots. The observations in the third division of the table were taken after the meter had been cleaned. These points are represented on the co-ordinate paper by small circular dots. The observations in the third division of the table were taken after the meter had been cleaned. These points are represented on the co-ordinate paper by small circles. It will be noticed that the curve they assume is so nearly a straight line that no appreciable error is made in considering it one and deducting its equation as such. The only point at which the curve departs from a straight line is at its lower extremity.

In finding the equation of this line the method of deducing the general equation of a straight line is followed. This method has already been described. The value of C, known otherwise as the intercept on the axis of Y, in this case is found by producing the straight line until it intercepts the axis of Y. The distance between 0, the origin, and the point of intersection is found to represent 0.08 revolution per second. In finding the value of M, which is the tangent of the angle made by the straight line with the axis Y, the following method is pursued. The tangent of this angle is represented by

$$\frac{Y-C}{X} = M.$$

Substituting values for X and the corresponding values of Y, and knowing the value of C, a number of values of M are found. These vary slightly because of inaccuracy in the measurement of the values of X, Y and C. In this case the value of M was found to be 2.64, so that, having determined both of the constants in the equation, the equation of the meter reads

$$Y = 2.64\,X + 0.08.$$

The rating table is prepared from this equation by substituting different values of X, or the number of revolutions per second, and solving for the corresponding values of Y. The intervals at which these values are determined vary with the accuracy required. Table III. is the rating table for Department meter No. 81, in which the computations were made for every 0.05 rev. per sec. from 0.05 to 2.50 revs. per sec.

TABLE III. Rating table, Department meter No. 81. Equation: $Y = 2.64\,X + .08$. Rated at Cheyenne, Wyo., Oct. 4, 1900.

Revolutions per second.	Velocity per second. Feet.	Revolutions per second.	Velocity per second. Feet.
0.05	0.35	1.30	3.51
.10	.43	1.35	3.64
.15	.52	1.40	3.78
.20	.63	1.45	3.91
.25	.75	1.50	4.04
.30	.87	1.55	4.17
.35	1.01	1.60	4.30
.40	1.14	1.65	4.44
.45	1.27	1.70	4.57
.50	1.40	1.75	4.70
.55	1.53	1.80	4.83
.60	1.66	1.85	4.96
.65	1.80	1.90	5.10
.70	1.93	1.95	5.23
.75	2.06	2.0	5.36
.80	2.19	2.05	5.49
.85	2.32	2.10	5.62
.90	2.46	2.15	5.76
.95	2.59	2.20	5.89
1.0	2.72	2.25	5.02
1.05	2.85	2.30	6.15
1.10	2.98	2.35	6.28
1.15	3.12	2.40	6.42
1.20	3.25	2.45	6.55
1.25	3.38	2.50	6.68

FIELD METHODS.

The following description of the three methods of current meter observations commonly in use, with a comparison of results under test, and the advantages of the third method over the others, was prepared for this journal by Mr. Johnston, as already stated:

Three common methods have been employed in the handling of current meters in the field. The first and probably the one most generally employed in the measurement of large streams is to divide the section into a number of small nearly equal squares or rectangles. In making a gaging, the meter is held in the center of each small section and the discharge at each is computed separately. The sum of the discharges at the small sections is the total discharge of the stream. This method has some advantages, but owing to the time it takes to make a gaging it seldom gives reliable results on streams where the fluctuations in discharge are at all rapid. The principal advantage that it affords is that no correction has to be made to the velocity as given by the meter. Whenever the meter is moved either vertically or horizontally in making a gaging, corrections should be made to the final results.

The second method is similar to the first except that the section of the stream is divided into small areas of equal width horizontally. The meter is moved vertically

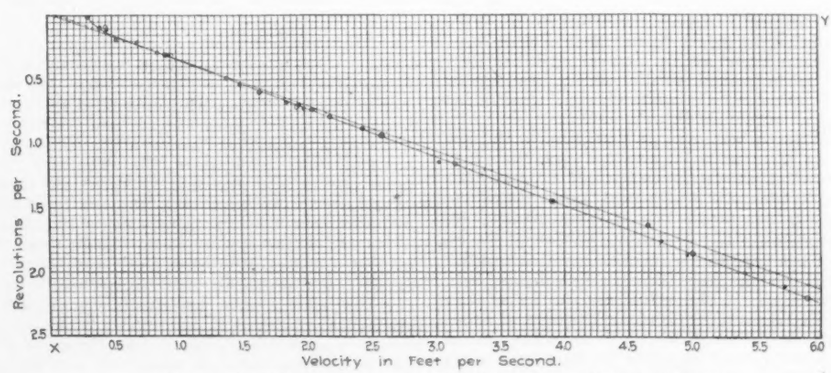


FIG. 2. RATING CURVES OF CURRENT METERS NOS. 68 AND 71.

from top to bottom through the center of each of these areas. The resulting velocity for each small area will likely be affected by the vertical motion of the meter. In the meters commonly used, however, this is quite small and can in most ordinary work be neglected. If gagings of this kind are to be made the meters employed should be tested when rated, to determine the effect of moving them vertically through still water. The second method is much quicker than the first, requiring about half as much time in making the actual meter runs, in addition to the saving in cross-section measurements.

In the third method the area of the section of the stream is measured and the meter is started at one end of the section. It is moved along the section on lines running at an angle of 45° to the horizontal. It has, therefore, both a vertical and a horizontal motion. In making the meter run the stop watch is started as the gaging begins and the number of times the meter crosses the stream on the section is recorded. Where the depth of water along the section varies greatly it may be advisable to record, also, the number of times the meter is lowered and raised. It is generally sufficient to cross the stream twice. The gaging, as far as the field work goes, is then completed. The correction for vertical motion is made the same as in the second method just described. The velocity after this correction has been made is the resultant of the true velocity of the stream and the velocity of the meter along the section. This resultant is the hypothenuse of a right-angled triangle and the velocity of the meter along the section is the base. The remaining side is the true velocity of the stream. This can be found graphically if more convenient then computation.

In the series of tests carried on by the Irrigation Investigations of the Office of Experiment Stations a canal 22 ft. wide and 2 ft. deep was measured. A weir just above the measuring flume enabled the discharge to be checked. With the first method the discharge fell below that given by the weir, the error being 4%. It required 22 minutes to make the gaging and 9 minutes to make the computation of the discharge. By the second method the discharge was too small, the error being 2%, and it required 13 minutes to make the gaging and 5½ minutes to make the computation. By the third method the discharge was too great by a little less than 1%. It required 2 minutes and 50 seconds to make the gaging and 4½ minutes to make the computation.

The third method can only be used to advantage where provision has been made for crossing the channel of the stream easily, and where the meter can be raised and lowered in the section. This may be impossible if the current is too swift, if the stage on which the observer stands is too high above the water, or if the water is too deep. The great advantage it has over the other methods is the speed with which the gaging can be made, permitting no change in the discharge during the time the work is being carried on. The product of the total area of the section and the mean velocity, taken from the rating table for the meter, after the corrections for the motion of the meter have been made, gives the discharge. While making the corrections adds some extra work, considerable saving in time is brought about by not having to find the discharge of a number of small sections separately before the final result is obtained.

JOHN BENJAMIN HENCK.

By Geo. F. Swain,* M. Am. Soc. C. E.

John B. Henck, for many years Professor of Civil Engineering at the Massachusetts Institute of Technology, and author of the well-known "Field-book for Railroad Engineers," died at his residence at Montecito, Cal., on Jan. 3.

Prof. Henck was born at Philadelphia, Oct. 20, 1815, of German parentage. He graduated at Harvard College with the degree of A. B. in 1840, having attained very high rank as a student, especially in the department of mathematics. He was a favorite pupil of Prof. Benjamin Pierce.

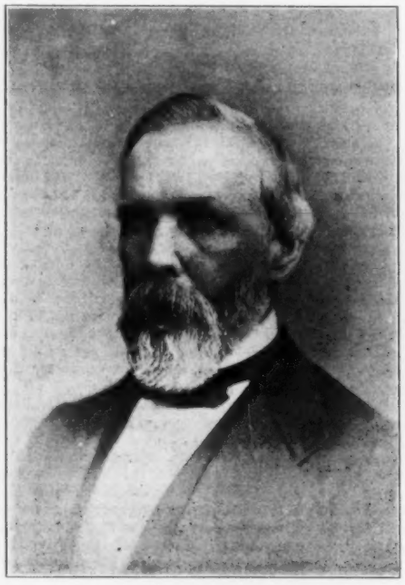
After his graduation he was for a year principal of the Hopkins Classical School, in Cambridge, Mass. In the following year he went to the University of Maryland, as Professor of Latin and Greek, in the Academical Department, and during five succeeding years he occupied a similar position in the old Germantown Academy, in Philadelphia.

In the year of his return to Philadelphia, 1843, he was married to Mary A. Kirby, the daughter of an old Quaker family of that city, and two sons were born there. He found the financial outlook, on the teacher's salary of those times, not sufficiently encouraging for a man with a growing family, and decided to turn his mathematical abilities to account in the field of civil engineering.

*Professor of Civil Engineering, Massachusetts Institute of Technology, Boston, Mass.

In 1846 he entered the office of Felton & Parker, Civil Engineers, in Charlestown, Mass., now a part of the city of Boston. Mr. Felton, of this firm, was the engineer for the Fitchburg Railroad, and Mr. Geo. Y. Wellington was the division engineer in charge of double-tracking the road with headquarters at Fitchburg. With this firm Prof. Henck had his first engineering experience. After remaining in the office about a year, he was sent to join Mr. Wellington's party at Fitchburg, where he stayed until 1850. He was then for a short time employed on the Eastern Division of the Cochituate Water-Works, which were at the time under construction for supplying the city of Boston. In this work he was under Mr. W. S. Whitwell, and in 1851 he formed a partnership with Mr. Whitwell under the firm name of Whitwell & Henck, with offices at 41 State St., Boston, the site of the present Exchange Building. This firm carried on a general engineering business and had some work to do in connection with the construction of the first street railways in Boston. In 1859 Mr. Whitwell retired from the firm to become Treasurer of the Boston & Roxbury Mill Corporation, and Mr. Henck carried on the business alone.

Probably the most important work which was undertaken by Mr. Henck's firm, and by Mr. Henck



John Benjamin Henck.

personally was in connection with the filling in and improvement of what is now the Back Bay district in Boston. This work was carried on by the Commonwealth of Massachusetts, and the firm of Whitwell & Henck was employed to do the engineering work, beginning in 1855. The work was under the direct authority, first, of the Commissioners of the Back Bay, then of the Land Commissioners, who had succeeded to the duties of the first-named Commissioners, and finally, in 1879, of a Board of Harbor and Land Commissioners, upon whom all work pertaining to harbors and public lands was finally concentrated. Mr. Henck continued in the employ of all these boards up to the year 1881, having charge of the work of filling in the land, laying out and paving the streets, and laying out the house-lots as fast as they were sold by the Commonwealth. It will interest many readers of Engineering News to know that the late A. M. Wellington, who so ably edited this paper for many years, was an articled student in Prof. Henck's office from 1863 to 1866.

In 1865, on the establishment of the Massachusetts Institute of Technology, Prof. Henck was chosen as the head of the Civil Engineering Department, and he continued to occupy this position until 1881, when he retired. During all the years of his professorship, as already mentioned, he was engaged in outside work, principally in the laying out of the Back Bay lands. In 1881, after retiring, he traveled for a few years, and finally settled at Montecito, Cal., where he passed in quiet the remainder of his life.

The principal work of Prof. Henck's life was that in connection with his professorship at the Institute of Technology. He established the department of Civil Engineering, organized the course of study, and determined the character of the instruction. To him as much as to any other one man is due the high standard of scholarship and attainment which was set by the Institute, and which soon gave the school a most enviable reputation, which it has ever since maintained. The principal characteristic of Prof. Henck was thoroughness and accuracy. He would tolerate no slipshod methods, but insisted upon a thorough and careful working out of each problem. He knew the distinction between teaching and merely giving information, and the students in his course were made to reason and think for themselves, instead of having their minds simply filled with facts. His own professional work was characterized by the same care and accuracy. In the work of laying out the Back Bay, and especially in laying out the house-lots, although the land was quite valuable, selling for from one dollar to five dollars per square foot, no question was ever raised as to the accuracy of his work. Indeed, he was, if anything, too particular and too accurate. The only criticism that could be made of him was that he sometimes carried refinements too far. The students used to say, jokingly, that Prof. Henck corrected his pacing for temperature. He was constitutionally unable to approximate, or to give a snap judgment, or to form a quick decision. It was always necessary for him to work a thing out thoroughly and accurately. He had, however, an exceptionally clear mind, and in working out his problems frequently devised original and simple methods of computation, which resulted in a great saving of time. His work upon the Fitchburg Railroad led him to devise his method for computing earthwork, which was considered very valuable by the other engineers; but in carrying out the corresponding fieldwork his associates generally considered him entirely too particular with reference to the degree of accuracy necessary.

Prof. Henck was probably best known to the engineering profession as the author of his "Field-book for Railroad Engineers," first published in 1854. This little book was a perfect model of careful, methodical, and concise mathematical presentation. In these respects it has never been excelled, and it stands to-day as a sample of what should be the ideal in books of this kind. It went through many editions, and will probably continue for some time to be a necessary part of the library of every railroad engineer. It is thoroughly typical of the man, and any one who is familiar with it can form a fair conception of his mental characteristics. His calculation and computation books, showing the work of his old firm and his own work when he succeeded to the business, are likewise models of clearness, and can be taken up to-day and read and understood by anybody.

As a teacher, Prof. Henck will be remembered and his death regretted by scores of former students, who have long ago forgotten what at the time they called his "fussiness," and who only remember his kindness of heart, his clearness of exposition, and the thoroughness of his teaching. As the first professor of Civil Engineering in one of the oldest of our engineering schools, his services to the cause of engineering education will not soon be forgotten by those who knew him, or who are in a position to appreciate what he accomplished.

Prof. Henck received the degree of A. M. from Harvard University in 1843, and was a Fellow of the American Academy of Arts and Sciences. He is survived by one son and one daughter.

WOOD PAVEMENT ON THE DRIVEWAY OF THE BROWN & SHARPE MANUFACTURING CO.

The accompanying view shows a portion of the main driveway at the works of the Brown & Sharpe Mfg. Co., at Providence, R. I., just after being paved with wood blocks. This roadway

sustains the heavy traffic incident to the delivery of iron, coal and limestone for the company's furnaces, the material, as we understand it, being dumped through manholes, some of which are shown in the view. The area paved comprises about 1,600 sq. yds.

The blocks are only 4 ins. deep, but are of Georgia pine, treated by the creo-resinate process controlled by the contractors for the work, the United States Wood Preserving Co., of New York city. The combination of creosote and melted resin is designed to act as a double preservative, guarding against both decay and abrasion. The resin is said to solidify in the fibers of the wood, rendering it waterproof and increasing its density and hardness.

For a foundation, 6 ins. of Portland cement concrete was used, and for a cushion coat 1 in. of clean fine sand was employed. The wood blocks were laid as close together as they could be forced by ramming, after which a coating of fine sand was spread over the surface and swept into any visible openings. After a few months of traffic it is said that the upper surfaces of the blocks expand sufficiently to obliterate the joints, leaving the surface smooth and uniform. It is also claimed that slipperiness is prevented by the resin.

No expansion joints were provided, the contractors stating that their experience shows no expansion by heat, wood being a poor heat conductor, and no swelling due to moisture, the blocks being non-absorbent.

WOOD BLOCK PAVEMENT ON THE DRIVEWAY OF THE BROWN & SHARPE CO., PROVIDENCE, R. I.

PLANT AND METHODS EMPLOYED IN EXCAVATING AMBROSE CHANNEL, NEW YORK HARBOR.*

The work is carried on under a continuing contract for the removal of about 42,500,000 cu. yds. of material at the rate of 9 cts. per cu. yd., in order to make a channel 2,000 ft. wide and 40 ft. deep at mean low water, the total length of channel to excavate being about seven miles. Under the requirements of the contract, the contractor was allowed one year to construct a plant (no excavation required), a second year with 3,200,000 cu. yds. excavation, after which it was expected the plant would be in complete working condition, and a rate of 9,600,000 cu. yds. per year was required.

After the award of the contract, the contractor examined the large suction dredges used in Liverpool, England (the "Branker" and the "Crow"), purchased the drawings and rights to all the improvements, and contracted for two dredges of (estimated) 50% greater capacity than the Liverpool dredges. From data furnished by the Liverpool harbor board he estimated that these two dredges would excavate about 1,200,000 cu. yds. per month, and not less than the required rate per year.

DESCRIPTION OF DREDGES.†

The two dredges, the "Thomas" and the "Mills," are built from the same drawings. The general plan of structure is for a twin-screw steel ship, 300 ft. long, 53 ft. beam, drawing about 13 ft. when light, pumping material into hoppers within its hold, from which the water overflows, carrying the sedimentary sand or mud away and depositing it in deep water.

The vessel is built with a longitudinal trunk well amidships, about 60 ft. long and 8½ ft. wide, extending down through the bottom of the ship. Through this well a 48-in. steel suction pipe, raised and lowered by a hydraulic piston, extends aft from the main pump and terminates in a nozzle, which is lowered to the bottom when dredging. The nozzle, 9 ft. long, is hooded over in extension of the top of the suction pipe, and is cut away to a curve underneath and fitted with gratings of 7-in. opening. The pump is a 48-in. centrifugal, made by a Baldwinsville, N. Y., pump company, and having a capacity of 80,000 gallons of water per minute; it is located forward, below deck, with axis transverse to the ship, and about at the light-draft water level; the suction pipe, just before reaching the pump, divides into a Y, in order to deliver material on both sides of the pump and avoid thrust.

The delivery pipe rises from the pump to about 4 ft. above the main deck, branches to both sides of the axis of the ship, and continues as two square, covered troughs; called "lander" troughs, to about 140 ft. aft of the pumps. Each trough has six pipes, controlled by butterfly valves, opening into the hoppers, six on each side of the vessel.

The hoppers are 18 ft. wide, 6 ft. on each side being covered by the deck, and the middle 6 ft. being open on top and walled in at the sides and ends to about 3 ft. height, forming "expansion tanks" designed to afford additional depth for material to settle. These tanks overflow on either side into longitudinal troughs, not quite as high as the tanks, and extending the full length of the six hoppers; there are four of these troughs; they empty the overflow into the sea through oval pipes running transversely through the upper part of each hopper and through the sides of the ship. There are twelve hoppers, eight of which are 20 ft. long (fore and aft) and four 22½ ft. long; they are 22.4 ft. deep, from the deck downward, the lower 6.2 ft. being an inverted truncated pyramid, of regular hopper form, the lower base 5 ft. square. When the twelve hoppers are loaded to the deck they contain 2,932 cu. yds. Dumping is effected through a circular opening 4½ ft. in diameter, covered by a lift valve with trunk of the same diameter rising nearly to the top of the hopper, to prevent the valve being weighted down by the load; valve and trunk are lifted by hydraulic power. The hoppers are provided with flushing pipes from the main pump, to facilitate discharge of dredgings, and also with jet pipes from the high-pressure pumps for use if the load becomes blocked.

The ships have quarters for day and night crews and electric light equipment for night work; they are said to have cost about $450,000 each. A full crew up to December, 1901, consisted of 54 men, with monthly pay roll of about $2,700; it has varied somewhat and generally been slightly reduced this year.

Several alterations have been made in the plant since the work began; the important ones are experiments with different widths of nozzle, with jet at nozzle to loosen material, and refitting the boiler room for oil fuel in place of coal. The comparative efficiency of different nozzles is not yet fully determined; probably it depends somewhat upon the kind of material dredged. The use of the jet has been abandoned for the present, the material dredged being mostly sand, which feeds freely to the nozzle. The use of oil for fuel is a recent modification, so far applied only to one of the ships; there is less loss of time waiting for steam pressure than when using ordinary grades of coal, but the results are nearly the same as with the best grades of coal.

The material excavated near the outer part of the channel is fine sand, gravel, small stones and clay, in varying proportions, but with the sand never less than 70% and the clay seldom exceeding 5%. The upper part of the channel contains mud and muddy sand; the dredge has not yet reached this material.

MANNER OF OPERATION.

The dredge is run up on the edge of the bar, the anchor dropped, and when the ship has swung true with the current the nozzle is lowered and the pumps started. In about ten minutes the wells fill with water up to the overflow and the draft of the ship increases 5 ft. or more. The nozzle sinks into the sand, rather quickly at first, excavating a sort of crater; where it is sufficiently deep (in the estimation of the operator—a variable depth, not infrequently 10 ft. below the depth required) the anchor chain is pulled in or slacked out, as the depths indicate, and the ship is thus moved about until loaded; it requires from three to six shifts to get a full load. Occasionally mistakes are made in moving, and the ship grounds during falling tide; then the valves are lifted and the material deposited in the channel.

The result of excavating each load is to make a trough in the bottom, the middle of which is below grade and the sides above grade. The width of the trough varies under different conditions of depth of cut, material, etc., but is much greater than the width of the nozzle.

At the beginning of work the suction pipes were broken several times by allowing the ship to drift over them in changes of wind or tide. A telltale device was put up, consisting of a line from the spring-stay down to the nozzle; whenever this is drawn out of marked limits it indicates danger to the pipe and the nozzle is lifted clear to the bottom at once.

The contractor made his first trial on the work Jan. 23, 1901, and began continuous work with one dredge April 4, 1901. The second dredge began June 10, 1901, and since then both have worked continuously, except when repairing. June 27, 1901, he began dredging by night as well as day, having previously provided gas buoys which were placed to mark the channel edges.

At occasional times these dredges have been remarkably efficient in excavating large quantities of sand; they do not sustain such rate for any length of time. The maximum efficiency of the pump for a single load was in August, 1901, when 2,850 cu. yds. of sand were excavated in 32 minutes, being at the rate of 5,344 cu. yds. per hour; revolutions of pump, 118 per minute; vacuum from 10 to 15 ins. The maximum day's work for one dredge is 21,624 cu. yds., and the largest month's work for one dredge 285,551 cu. yds.

The average efficiency of each pump for eleven months ending May 31, 1902, has been 1,440 cu. yds. of sand per hour of pumping. The time occupied in pumping, taking away, and dumping an average load, about 2,500 cu. yds., is 3 hours and 50 minutes, divided up as follows: Pumping, 1 hour 45 minutes; going to the dumping grounds and returning (round trip of 12 miles at present), 1 hour 50 minutes; dumping, 15 minutes.

Out of the 562 working days (281 for each dredge) work was actually done on 442 days, 88 days being used in making repairs and 32 days lost by bad weather. During the 442 days of work, the dredges averaged 15¼ hours per day, the lost time being chargeable to minor repairs, weather, coaling, and no inconsiderable part to inability to keep up steam.

EXAMINATIONS OF CHANNEL.

The dredges make very uneven bottom, and as the contract allows no payment for material excavated below the required depth of 40 ft., mean low water, frequent examinations are necessary to furnish data for estimating the overdepths.

Soundings are taken with a rod which must be over 60 ft. long to reach the deepest work of the dredges; such a rod cannot be raised and lowered by hand—it is worked from the boom on the steamer "Manisees." It has been found that a rod made of sections of iron pipe is less liable to break than a wooden rod of necessary length, and the increased weight is of little account, using steam hoist. With every precaution and using special steel couplings 6 ins. long, the rod will sometimes break or bend where the current is running strong and the bottom suddenly changes from deep to shoal. Soundings can only be taken from a boat going with the current, or in still water; no rod of required length will stand against the current.

The location of the work is four miles from the nearest shore, and still days are often too hazy to see clearly for this distance; therefore the soundings are located by transits mounted on iron tripods in the bay at convenient points near the channel; the tripods are made of 3-in. iron pipe with platform on top; they are about 30 ft. high.

These examinations show depth in the dredged channel ranging between extremes of 29 and 60 ft.

The last estimate of amounts dredged below the required depth, made up to May 31, 1902, showed that out of 4,984,-

*Abstracted from the report of Mr. Henry N. Babcock, U. S. Assistant Engineer, printed in Appendix Z Z of the Annual Report of the Chief of Engineers for 1902.

†A full description of these dredges was published in Engineering News of Feb. 14, 1901.

239 cu. yds. total excavation 865,497 cu. yds. were from below 40 ft. depth, and could not be paid for under the contract. The proportion of such overdepth work has generally been found to be in the neighborhood of 16%.

GENERAL COMMENTS.

The original plans for the dredges provided for a drag mouthpiece to excavate material while moving slowly over the bar. The Liverpool nozzle was substituted on account of its high efficiency in getting material, but before completing the contract it will apparently be necessary to use some other plan to grade down the ridges. The contractor expresses confidence that these inequalities will gradually level off by tide or wave action. Up to the present time this confidence rests more upon hope than upon experience.

The dredges find much trouble in reducing the depths on the crest of the bar. The water is about 15 ft. deep at low tide and the ships draw 23 ft. loaded; they can work in the shoal water only for a short time when the tide is high. By dredging to full depth as close to the shoal water as the dredges can go, the bank is drawn into the cut a little, and a slow progress is made into the shallow part of the bar. Attempts to hasten this progress have done more than once, where the depth is already 44 ft. or more.

The dredges as built are powerful machines, capable of excavating very large quantities of sand; they require careful and experienced management to get out of them the best work which they can do.

In the eleven months preceding May 31, 1902, the two dredges excavated 4,561,030 cu. yds of sand; after deducting the amount dredged from below 40 ft. there remained 3,747,596 cu. yds. which were paid for at the rate of 9 cts., amounting to (retained percentage included) $337,283.64. The cost of operating the dredges was originally estimated by the contractor at $6,000 per month each; it has not amounted to so much and probably would average not over $4,500. He estimates the cost of building the two dredges, with modifications of plans, at about $950,000. The cost for the eleven months would then be approximately:

Operating expenses, two ships at $4,500 each per month	$99,000
Interest on $950,000 at 5%	43,540
Total	142,540

leaving a balance of about $195,000 to cover repairs, deterioration of plant, superintendence, and other items.

The cost of repairs during these eleven months has been very high. I have no means of estimating it. It appears that the balance is large enough to show quite a margin for profit at the contract price of 9 cts. per cu. yd.

been made by exploding dynamite on the shoal near the bank; they have not yet been successful, and as a practical and economical mode of work they will not be. At the beginning of work the contractor was positive that his two dredges could excavate the amount required by the contract, 9,000,000 cu. yds. per year, basing this belief on the efficiency of the Liverpool dredges. It is now apparent that they cannot accomplish this.

The largest month's work yet done was in October, 1901, when two dredges removed 552,297 cu. yds. The largest day's work for one dredge is 21,624 cu. yds., which is nearly twice the average for days of actual work. It ought to be possible to bring the average nearer to the maximum than 52%.

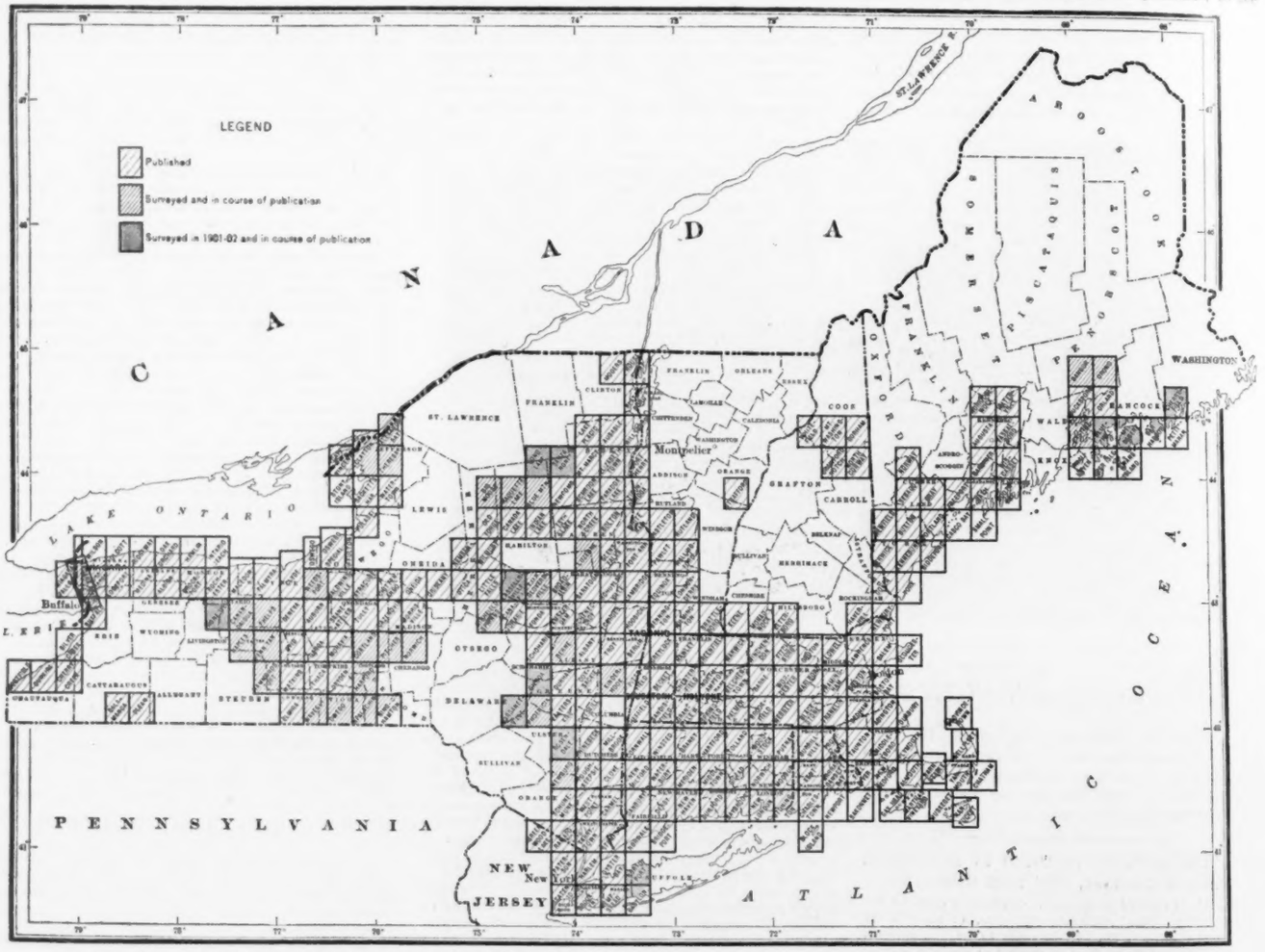
Sixteen per cent. of the excavation is below the required depth and is not paid for. This is altogether too large a proportion and with careful management it ought to be much reduced, probably to 6 or 8%. It cannot be wholly avoided without unduly increasing the cost of operation, but it is quite unnecessary to begin dredging, as has been

PROGRESS OF THE TOPOGRAPHIC MAPPING OF THE U. S GEOLOGICAL SURVEY.

No scientific work done by the Government has shown more direct or quicker returns for the money expended than the topographic surveys and maps made by the U. S. Geological Survey. To an engineer engaged in surveying a railway line, in designing a water supply system, or even in proportioning the size of a comparatively small culvert, these topographic maps are often of inestimable value. It frequently happens, however, that the engineer does not know that a particular section has been thus mapped; and we recall several instances where a considerable expenditure of time and money was made in practically duplicating surveys already made by the U. S. Geological Survey.

In order that engineers and others having occasion to use these maps may readily find whether a particular section has been surveyed and mapped, as well as to show the area covered by each map sheet, the Survey issues index maps which are sent free on request, and which show at a glance the area already mapped, that of which maps are in process of preparation and also the area still untouched.

We reproduce herewith one of these index maps (reduced about one-third from the original) showing the progress made to date by the Survey in New York and New England. It will be a surprise to many of our readers, we presume, to see



INDEX MAP SHOWING PROGRESS OF TOPOGRAPHIC SURVEYS AND MAPPING IN NEW YORK AND NEW ENGLAND BY THE UNITED STATES GEOLOGICAL SURVEY.

The cost of repairs during these eleven months has been very high. I have no means of estimating it. It appears that the balance is large enough to show quite a margin for profit at the contract price of 9 cts. per cu. yd.

PROGRESS OF THE TOPOGRAPHIC MAPPING OF THE U. S GEOLOGICAL SURVEY.

No scientific work done by the Government has shown more direct or quicker returns for the money expended than the topographic surveys and maps made by the U. S. Geological Survey. To an engineer engaged in surveying a railway line, in designing a water supply system, or even in proportioning the size of a comparatively small culvert, these topographic maps are often of inestimable value. It frequently happens, however, that the engineer does not know that a particular section has been thus mapped; and we recall several instances where a considerable expenditure of time and money was made in practically duplicating surveys already made by the U. S. Geological Survey.

In order that engineers and others having occasion to use these maps may readily find whether a particular section has been surveyed and mapped, as well as to show the area covered by each map sheet, the Survey issues index maps which are sent free on request, and which show at a glance the area already mapped, that of which maps are in process of preparation and also the area still untouched.

We reproduce herewith one of these index maps (reduced about one-third from the original) showing the progress made to date by the Survey in New York and New England. It will be a surprise to many of our readers, we presume, to see what a large proportion of this section has now been mapped. Each atlas sheet is 16½ × 20 ins., and the ordinary scale is 1 in 62,500, but where the country is very rough the scale may be 1 in 125,000, or even 1 in 250,000. In the last-named case an atlas sheet measures 1° each way.

Contour lines are drawn usually at 20-ft. intervals. As most of our readers know, the contours are printed in brown, water in blue, and other features such as roads, railways and buildings in black. The atlas sheets are sold for 5 cts. each, or $2 per hundred. Geologic folios are also being published, showing the areal geology, underground structure, etc., in colors and patterns, as well as contours. The price of the folios is 25 to 50 cts. each, and the names of the folios in print may be had upon application to the Director of the U. S. Geological Survey, Washington, D. C.

A CONCRETE-STEEL CULVERT FOR STREAM DIVERSION AT KALAMAZOO, MICH.*

By Geo. S. Pierson,† M. Am. Soc. C. E.

Through the city of Kalamazoo flows a stream called Arcadia Creek. This stream drains an area of about 3,750 acres. The basin of which this stream is the natural drainage is about five miles in length, east and west, and about 2½ miles in width, north and south, in its greatest dimensions. About 3,000 acres lie outside of the city limits and about 750 acres lie within the city limits. The length of the stream within the city boundaries is about 12,600 ft.

Up to the commencement of the work described in this article no systematic improvement or even protection of

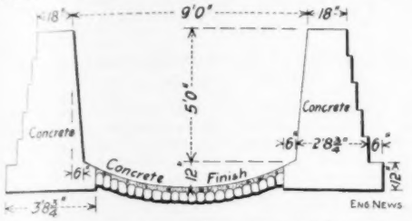


Fig. 1. Cross-Section of Open Channel for Stream Diversion at Kalamazoo, Mich.

the channel of Arcadia Creek in the business portion of the city was attempted. Numerous bridges and culverts have been built over it which varied greatly in size and form and were placed without reference to any proper gradient of the stream. In some instances, piles had been driven into it to support buildings; building foundations had encroached upon it; railroad culverts of too small capacity had been built and the sides of the channel had been lined with planking, which restricted its flow to such

Fig. 2. I-Beam and Reinforced Concrete Construction to Carry Streets Over Open Channel.

a degree, that, during floods, the basements of buildings were flooded and serious damage done.

As pavement areas have been extended in the city and storm sewers which discharge into the stream have been extended from year to year, these conditions have been aggravated. During the last 25 years numerous attempts have been made by parties interested to bring about some improvement in the channel. These resulted in no concerted action until in the spring of 1902, when a bond issue was authorized by general vote, to improve that portion of the channel below Burdick St. and the work was put in charge of commissioners appointed for that purpose.

Burdick St. lies in about the center of the business portion of the city and the distance from this point to where the stream discharges into the Kalamazoo River is about 3,764 ft. This portion of the stream runs under many business blocks, crosses seven streets and twelve railroad tracks and side tracks. The city has a system of sewers and the main sewers lie at a lower level than the stream and cross under it in several places. Many of the foundations of buildings along the stream do not extend below the level of its bed and the same may be said of the foundations of bridges which span it. In some places, therefore, no radical change in the elevation of the bed of the stream could well be made and it was not feasible to lower the bed of the stream to a degree which would otherwise have been advisable. A limit was in like manner set upon the depth of a new channel by street grades, yard areas, and the floors of buildings which had long been established and to which the surface must closely conform.

DETERMINATION OF CROSS-SECTION.

It was a difficult matter to forecast the maximum flow to be provided for in the new channel. A survey of the entire watershed was made, and also a detailed survey of the entire channel within the city limits. The cross-section of the stream at all points where there were culverts, buildings, tunnels and other permanent construction was measured; the depth of the foundation footings was measured and a profile of the stream was made on which was platted these various cross-sections in their true position.

All the information obtainable in regard to flood elevations was marked on this profile and a rough approximation to the greatest discharge up to this time was made. Shortly after the project was started, there occurred two rather severe floods though not as severe as have been known at other times. During these floods in 1902, a record was kept of the stage of the water at numerous points along the stream and the maximum height to which the flood rose was platted upon the profile. This information was important and assisted in forming a conclusion as to the probable maximum discharge which should be provided for. Computations were also made of the probable future discharge of areas within the city limits, and from this and other information of like character the size of the proposed channel was fixed. The position of the bottom of the channel was determined from the depth of footings of the more substantial buildings along the route. Less important footings were replaced or strengthened where it was desirable to lower the grade at these points.

OPEN CHANNEL CONSTRUCTION.

The conditions in the business portions of the city did not allow an arched construction owing to the lack of head room and cover. There were also numerous places along the channel where the side walls were substantially built and where the area of section was sufficient. These it was desired to retain, and, as they occurred at frequent intervals, no continuity of construction would have been possible if an arched section had been adopted.

The cross-section shown in Fig. 1 was adopted for this portion of the work. The footings were placed as low as the adjoining foundations permitted, and the flow line still farther lowered by an inverted arch placed between the side walls, as shown in the drawing. At some places where the walls already in place did not afford sufficient capacity, one of the old walls was retained and faced with concrete and the opposite wall was removed and replaced by a new one, the alinement of the channel being rectified as much as possible. In some places it was necessary to remove the entire foundations of heavy buildings and to replace them by one of the side walls.

All of the side walls were built of concrete composed of sand, gravel and Portland cement. It was necessary to do this work without interrupting the flow of the stream and consequently it was diverted alternately to one side and the other of the channel. The inverted arch is laid of cobble stones taken from old cobble gutters near at hand and laid in Portland cement.

At street crossings, steel I-beams were laid upon the side walls. Woven steel wires were placed across the I-beams, as shown in Fig. 2, a platform was supported beneath the whole, and concrete was tamped about and over the I-beams to carry the traffic. The surface of this concrete is about 5 ins. below the established grade of the street so that when paved the surface of the pavement will be continuous over the bridge.

ARCH CULVERT CONSTRUCTION.

At a point about 1,500 ft. from the old outlet of the stream the natural channel makes a detour toward the north and cuts through many of the city lots in such a way as materially to diminish their value. From this point, an alley extends directly east toward the river, and by purchase of a short right of way over private property it was possible to shorten the length of channel about 700 ft. and to improve the conditions in this part of the city very much. This route was therefore adopted for the new construction.

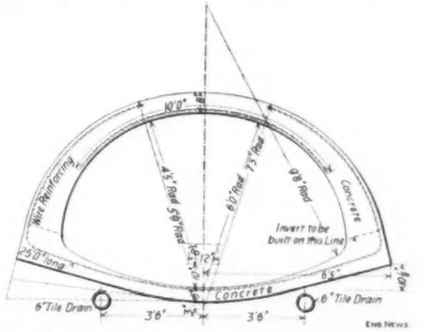


Fig. 3. Cross-Section of Reinforced Concrete Culvert for Stream Diversion at Kalamazoo, Mich.

In this portion of the work there was sufficient head room for an arched cross-section. In fact, a covered construction was necessary in order to preserve the utility of the alley and in order to secure the private right of way at a reasonable figure. This portion of the new channel was constructed as shown in Fig. 3, and it is to this part of the work to which this article more particularly refers. The work was done entirely by day labor, under the direction of the commissioners and under the charge of a competent foreman experienced in the handling of concrete. It is 1,080 ft. long; was commenced Nov. 3, 1902, and finished Jan. 10, 1903. The form of cross-section is shown in the illustration. The dimensions are 9 ft. and 10 ins. in the clear, horizontally; and 6 ft. in the clear, vertically. The grade varies from 0.4 to 0.5%.

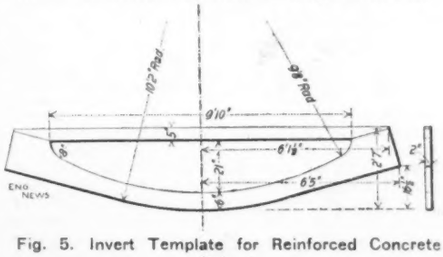


Fig. 5. Invert Template for Reinforced Concrete Culvert.

FIG. 4. VIEW SHOWING INVERT CONSTRUCTION OF REINFORCED CONCRETE CULVERT.

Most of the excavating was done by wheeled scrapers. The masonry is entirely of concrete composed of sand, gravel and Portland cement. The proportions are generally about one part of Portland cement to six parts of sand and gravel. The upper arch, however, was made of a somewhat richer concrete than this, and the lower arch with a somewhat poorer concrete. These proportions were not rigidly adhered to, the composition being generally made richer under street crossings where there is a light covering of earth, and also where particularly treacherous soil underlaid the foundations.

The section is reinforced by a woven steel wire fabric, shown in the cross-section. The members of this fabric which extend around the sewer are of No. 11 steel wire and two layers of the fabric are used in all cases, thus making a total length of wire surrounding the sewer of 175 ft. per lin. ft. There is an average of about five wire per lineal foot, enclosing the conduit, except where the outer and inner reinforcements overlap, in this case there is double this number.

The bearing portion of the concrete in the inverted arch was changed in form, as shown by the dotted lines, Fig. 3, according to the character of the earth on which the concrete was to be laid. In some parts of the work the

*Abstract of a paper read at the annual meeting of the Michigan Engineering Society, Jan. 20-22, 1903.

†Consulting Engineeer, Kalmazoo, Mich.

conduit rests on rather soft material. For a considerable portion of the way it rests upon quicksand. In ground of this character, two lines of tile drains are laid under the invert of the sewer, and these, by removing the excessive water from the quicksand, made it firm and a good foundation.

Fig. 4 is a view taken during construction in this material. The lower portion of the invert of the conduit was brought to a true form by means of a straight edge sliding on transverse templates, shown in place in the view and in detail by Fig. 5. At the sides, the concrete was packed in behind forms which are held in place by transverse hinged struts, also shown in the view and by Fig. 6. At this height the concrete was brought to a slightly

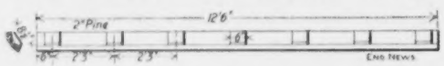


Fig. 6. Side Form for Reinforced Concrete Culvert.

inclined surface so as properly to receive the thrust of the upper arch and was roughened so as to make a proper bond with it. The reinforcing metal laid in the invert is in one continuous piece, extending up nearly to the crown of the arch, as shown in Fig. 3. In the views the part of this metal which is to be imbedded in the upper arch is plainly to be seen.

Fig. 7 is a view showing a section of the upper arch with the centering and templates on which it was built still in place. In building the upper arch, the concrete was well rammed against substantial, tightly boarded centers, Fig. 8, which rested upon the invert form and was also supported at the crown by struts resting upon plank lying along the invert. Planks were placed longitudinally on the exterior of the arch along its lower portion to confine the concrete to the proper form and to hold it in position so that it could be thoroughly compacted. Nearer the crown of the arch no such outside form was used. The exterior of the upper arch was brought to the proper form by a straight-edge sliding along transverse templates, Fig. 9.

Fig. 10 is a view of the upper arch during construction and shows the templates and wire netting. In the same view can be seen a portable bridge which was moved along as the work progressed.

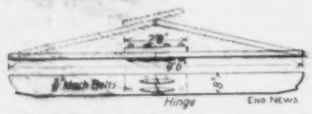
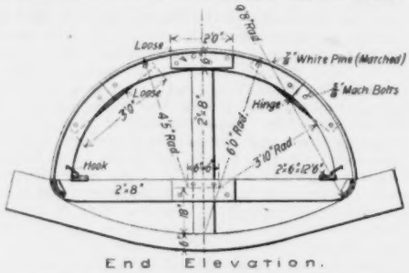


Fig. 11. Hinged Cross Brace for Centers for Reinforced Concrete Culvert Construction.

The centers were built in sections 12½ ft. long (Fig. 8), and a sufficient number was provided to lay twelve sections of invert and six sections of arch. The templates and centering are all arranged so they can readily be taken down without any jarring of the concrete. The upper forms are hinged at the quarters, can be separated in two pieces and folded together so that those farthest back in the conduit, where the concrete has had more time to set, can be brought forward through those which have been set in more recent construction and where the concrete is still fresh. All of the centering is loosened by unbolting a piece which spans the hinged joint in the center of the struts, Fig. 11, and then moving the center of the struts laterally.

In work of this kind it is very important to have the centering absolutely rigid so that it will not spring when concrete is being tamped against it and thus weaken the cohesion of the concrete. It is also important to have the arrangement such that all the centering can be removed without straining or jarring the fresh concrete. The centers were generally removed in about three or four days after the concrete arch was in place. Before backfilling about the arch its exterior was well brushed with neat Portland cement mixed with water. The interior of the conduit was also finished in the same way.

Much of the work of construction was done when the thermometer, during working hours, ranged from 12° to 25° above zero. When the temperature was below freezing, hot water was used in mixing the concrete, and on a few of the coldest days, salt was dissolved in the water. The work was never discontinued on account of cold, but was discontinued during several storms of sleet. In cold or stormy weather each section of concrete was covered with oiled canvas as soon as completed, and the conduit



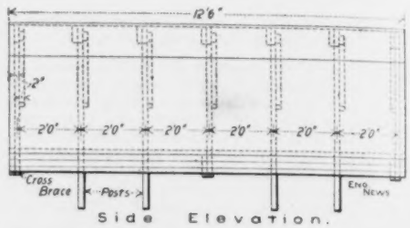


FIG. 8. DETAILS OF TIMBER CENTERS FOR REINFORCED CONCRETE CULVERT CONSTRUCTION.

was kept closed at each end, so far as practicable, in order to retain the heat.

At two points it was necessary to depress the water mains, and at one point an inverted siphon was required in a main sewer. Where the conduit crossed under railroads, the section was modified by carrying the side walls up vertically and supporting the traffic upon heavy iron I-beams.

This conduit is intended to remove only the storm water which naturally flows from the valley and the discharge of surface water from the streets. The sewage proper of the city is provided for in other channels and its discharge into this conduit is not allowed.

The following tables I. and II. were compiled from accounts kept during the progress of the work. Table II. shows the actual cost of the masonry in place and includes the cost of all the work, except the rough excavation, which is omitted for the reason that it often varies widely, has no general application, and is of less interest. The cost of superintendence, tools, etc., is included, but the cost of engineering and general administrative expenses are not included.

Combinations of concrete and steel are rapidly growing in favor for various kinds of construction both here and abroad. In certain lines of construction the details have been the subject of extended study and experiment, and the general arrangement follows well established principles. It is believed that this form of construction may often be used with great advantage in sewers and conduits, and it seems probable that its use in structures of this kind will be materially extended in the immediate future. Up to the present time, however, the details of this class of work have not received as much attention as

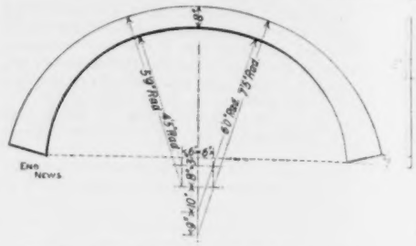


Fig. 9. Arch Template for Reinforced Concrete Culvert.

in the case of beams, floors and similar work. In work of this class the stresses can be readily computed and the construction can readily be tested in an experimental way. In the case of a sewer, it is difficult to compute the stresses to which the shell may be subjected and difficult to subject a section experimentally to the strains which occur in practice. This subject, therefore, opens up an interesting field for investigation.

A NEW LATHE, built by the American Tool Works Co., of Cincinnati, Ohio, is remarkable in that it will cut 44 different threads without the removal of a single gear and without stopping the machine. The feeds per inch range from 8 to 128. A cone of 11 gears in connection with a four-speed box serve to secure the 44 threads.

SHIPBUILDING IN GREAT BRITAIN for 1902 shows a total of 823 vessels of 1,451,995 gross tons, as compared with 672 vessels of 1,671,798 gross tons in 1901.

FIG. 7. END VIEW OF REINFORCED CONCRETE CULVERT, SHOWING CENTER IN POSITION.

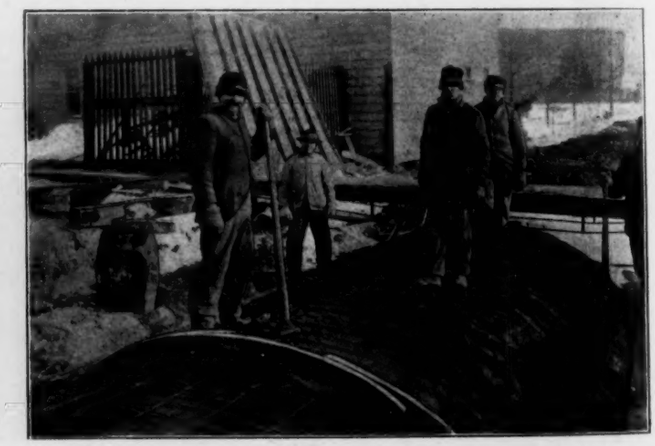


FIG. 10. VIEW SHOWING ARCH OF REINFORCED CONCRETE CULVERT UNDER CONSTRUCTION.

TABLE I.—Showing Labor Force, Material Used and Progress of Work on Kalamazoo, Mich., Stream Diversion Culvert.

Average progress per day in feet	18.6
Greatest number of feet laid in any one day	28.
Average No. of laborers per day mixing & wheeling	10.04
Average No. of laborers per day placing concrete	5
Average No. of laborers per day setting up forms	4.57
Cu. yds. concrete mixed & wheeled per day per man	1.96
Cu. yds. of concrete placed per day per man	3.54
Cu. yds. of concrete per lineal foot	0.95
Barrels of cement per lineal foot	1.18
Barrels of cement per cubic yard	1.24
Proportion of cement to sand and gravel	1.6

TABLE II.—Showing Itemized Cost per Lineal Foot of Concrete-Steel Culvert at Kalamazoo, Mich.

Sand and gravel	$0.42
Cement	2.44
Mixing and wheeling concrete	0.98
Labor placing concrete	0.47
Forms and templates	0.30
Metal fabric	0.39
Setting up forms	0.43
Finishing	0.09
Tools, general expenses and superintendence	0.43
Total cost of masonry per lineal foot	$5.95